TRANSCRIPT OF RECORD.

SUPREME COURT OF THE UNITED STATES.

No. ~~358~~.

THE KEYSTONE BRIDGE COMPANY, APPELLANT,

vs.

THE PHŒNIX IRON COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE EASTERN DISTRICT OF PENNSYLVANIA.

FILED DECEMBER 10, 1872.

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1 Pleas and proceedings before the honorable judges of the circuit court of the United States in and for the eastern district of Pennsylvania, in the third circuit, of October session, 1867, No. 45.

It is thus contained:

Be it remembered that, on the sixteenth day of January, in the year of our Lord eighteen hundred and sixty-eight, The Keystone Bridge Company, by Theodore Cuyler, esquire, come into our said court
2 here and file of record their bill of complaint against The Phœnix Iron Company, Samuel J. Reeves, and George H. Sellers, which said bill being read is as follows, to wit:

3 In the circuit court of the United States, in and for the eastern district of Pennsylvania, sitting in equity.

The Keystone Bridge Company, a corporation created by and existing under the laws of the State of Pennsylvania, bring this their bill of complaint against the Phœnix Iron Company, also a corporation created by and existing under the laws of the State of Pennsylvania, and Samuel J. Reeves and George H. Sellers, also citizens of said State, and thereupon the said complainant shows:

First. That they are a corporation of the State of Pennsylvania largely engaged in the business of manufacturing, building, and constructing iron bridges, for railway and other uses.

Second. That they have acquired by purchase, for a valuable consideration, and now own the right to use and employ certain new, useful, and valuable improvements in the construction of bridges, and other structures designed to carry heavy weights, which were heretofore invented and made by James H. Linville and John L. Piper, and for which letters patent of the United States were duly issued to said Linville and Piper.

Third. That one of said letters patent is entitled, "For improvements in iron truss-bridges," and was issued on the 14th day of January, A. D. 1862, and is numbered 34183; and the other is entitled, "For improvements in wrought-iron bridges," and is numbered 50723, and was issued October 31st, A. D. 1865; copies of both of which letters patent, marked respectively "A" and "B," will be attached to and exhibited with this bill, and are made part of the same.

4 Fourth. Complainants possess the exclusive right to use and employ said patents, and to manufacture, build, and construct bridges and parts of bridges, and other structures designed to bear heavy weights, under the same, excepting only that said Linville and Piper have reserved the right to use and employ both of said patents; and the Pennsylvania Railroad Company have a concurrent right to use the first mentioned of these patents, Exhibit "A." With these qualifications, complainants have the absolute and exclusive right to use and employ these two patents, and to construct bridges and parts of bridges, and other structures designed to bear heavy weights under the same.

Fifth. The inventions secured by the said respective letters patent were made in the year 1860 and 1861, and are of great value and importance in the construction of iron truss-bridges, and other structures to bear heavy weights, and have been extensively introduced by complainants, who have erected costly machinery, and invested a very large amount of capital for the purpose of manufacturing and construct-

ing, in accordance with said patents, which have now become well known, and are recognized as founded upon true principles, and embodying almost indispensable requisites for the safe construction of bridges over which great weights are intended to be passed, or of other structures designed to bear heavy weights.

Sixth. The said defendants are infringing upon the rights of complainants by using and employing the inventions which are secured to complainants by the aforesaid letters-patent, and are offering to construct bridges, and to manufacture, at their works at Phœnixville, in the State of Pennsylvania, posts for wrought iron truss-frames, to be employed in the construction of bridges such as are substantially identical with those described in the second claim of the said letters-patent No. 34183, bearing date January 14, 1862, and in the first claim of the said letters-patent No. 50723, bearing date October 31, A. D. 1865;

also by the construction of the upper chords or compression-
5 beams formed by a combination of "I" shaped roller-beams or channel-bars riveted to plates of wrought-iron so as to form in each chord a series of rectangular tubes or cells intended thus to secure great transverse strength to support the weight of passing trains of railroad cars or other heavy weights, combined with great resistance to compressive force, substantially such as are described in the said letters-patent No. 50723.

Also by the construction of the lower chords of truss-frames for bridges out of wide and thin rolled bars of wrought iron, the eye end of which is enlarged, and is formed by upsetting the iron when intensely heated by compression, into moulds of the required shape, for the purpose of increasing the density, roughness, and strength of the eye of the rod, and of enlarging the eye without diminishing the transverse section, substantially such as is described in the first claim of the said letters-patent No. 34183, bearing date January 14, A. D. 1862, and in the third claim of the said letters-patent No. 50723, bearing date October 31, A. D. 1865.

Seventh. The said defendants allege and pretend that they have rights, by virtue of the letters-patent of the United States, and that they are acting in according with the letters-patent so issued to or held by them. Whereas complainants aver and expressly charge that J. H. Linville and J. L. Piper, from whom they have derived title in the said invention, were the first and original inventors of the several improvements in said letters-patent described, and that knowledge of the said improvements so invented by the said Linville and Piper, from whom complainants derive their title to use the same, was surreptitiously obtained by respondents from said Linville and Piper, and that such letters-patent as respondents set up and pretend that they are protected by, were obtained in fraud of the rights of said Linville and Piper, and of complainants, as their assignees.

And complainants further show that the said Samuel J. Reeves obtained letters-patent of the United States on the 17th June, 1862,
6 No. 35582, for improvements in the construction of columns, shafts, braces, &c.; and the said George H. Sellers obtained letters-patent of the United States on the 29th March, 1864, No. 42147, for improvements in the manufacture of bar-links—both of which letters-patent have been assigned to the Phœnix Iron Company—the said Reeves and Sellers being both of them officers and employees of said company, and that both of said letters-patent were obtained in fraud of the rights of complainant, and with full knowledge of the prior invention of the

said Linville and Piper now held by complainant, and that both of said letters-patent infringe upon the rights of complainants aforesaid.

Wherefore complainants have need of equitable relief as follows, viz:

First. That now by the special and preliminary, and hereafter by the final decree of the court, the defendants may be restrained from infringing upon the rights secured to complainants by the aforesaid letters-patent No. 34183, bearing date January 14, A. D. 1862, and 50723, bearing date October 31, A. D. 1865.

Second. That in like manner defendants may be restrained by the decree and injunction of the court from setting up, alleging, or pretending that any rights whatsoever are derived or secured to them by the aforementioned letters-patent, which it is averred in the previous parts of this bill were obtained in fraud of the rights of complainants.

Third. Such further and other relief as to the court may seem meet, and as may be consistent with the practice of courts of equity.

Fourth. That process may issue.

THO. CUYLER,
Complainants' Solicitor.

, being duly sworn according to law, doth depose and say, that the statements made in the foregoing bill of complaint are just and true, to the best of his knowledge, information, and belief.

7 And afterwards, to wit, on the twenty-sixth day of May, in the year last aforesaid, the said defendants, by Furman Sheppard, esquire, their solicitor, come into court here and file their answer to the bill of complaint, which being read is as follows, to wit:

8 In the circuit court of the United States, in and for the eastern district of Pennsylvania, sitting in equity.

THE KEYSTONE BRIDGE COMPANY *vs.* THE PHŒNIX IRON COMPANY ET AL. } October sessions, 1867. No. 45.

The joint and several answers of the Phœnix Iron Company and of Samuel J. Reeves and George H. Sellers, defendants, to the bill of complaint of the Keystone Bridge Company, complainant.

These defendants, now and at all times hereafter saving and reserving unto themselves, and each of themselves, all and all manner of exception which can or may be had or taken to the numerous errors, uncertainties, and imperfections in the said complainants' said bill of complaint contained, nevertheless for answer thereunto, or unto so much and such parts thereof as these defendants are advised is material or necessary to be answered unto, answering, say:

That they do not know, and have not been informed, save in and by said bill, and that they do not admit that the said complainant has acquired by purchase or otherwise the right to use and employ the alleged improvements in the construction of bridges and other structures designed to carry heavy weights, for which the respective letters-patent in said bill mentioned and referred to were granted to the said

9 Jacob H. Linville and John L. Piper; nor do these respondents know, nor have they been informed, save in and by the said bill, nor do they admit that the said complainant possesses the exclusive right to use and employ said letters-patent in manner and form as in said bill mentioned; but these respondents respectfully submitting that

said bill of complainant does not duly and properly set forth any adequate, sufficient, or legal right, title, or interest in the said complainant under said several letters-patent, or any adequate, sufficient, or legal right to maintain these proceedings in the name solely of the said complainant without the joinder of other parties as co-plaintiffs; and reserving unto themselves the benefit and advantage of said exception and objection, pray that the said complainant may be compelled to make due proof of all and singular the allegations of said bill in that behalf.

And these respondents, further answering, say that they do not know and have not been informed, save in and by said bill, and do not admit that the said Jacob H. Linville was the true, original, and first inventor of the alleged improvements described and claimed in the said letters-patent granted to said Linville bearing date January 14th, 1862, or that the said Jacob H. Linville and John L. Piper were jointly, or that either was severally the true, original, and first inventor of the alleged improvements described and claimed in the said letters-patent granted to them jointly bearing the date October 31, 1865; but these respondents say that they have been informed and that they believe that the said Jacob H. Linville and John L. Piper were not the true, original, and first inventor of the said alleged improvements, and they pray that the said complainants may be compelled to make due proof of all and singular the allegations of said bill in that behalf.

And these respondents, further answering, say that they the alleged improvements described and claimed in the said respective letters-patent granted to the said Jacob H. Linville and John L. Piper, or the substantial and material parts thereof, claimed by them as new and original, were, (except so far forth as the improvements claimed by them in said letters-patent bearing date October 31, 1865, were and are an unlawful attempted appropriation of improvements mentioned and described in letters-patent of the United States, granted to Samuel J. Reeves, one of these respondents, and bearing date June 17, 1862, and to George H. Sellers, one of these respondents, dated March 29, 1864, as hereinafter more fully mentioned,) prior to the alleged invention or discovery thereof by the said Jacob H. Linville and John L. Piper, well known to and publicly used by divers persons in the United States, England, and elsewhere, and were mentioned, described and represented in divers printed publications or public works in the United States, England and elsewhere, whereby, as these respondents respectfully submit, said letters-patent were and are null and void.

And these respondents, further answering, say that the alleged improvements, described and claimed in the said letters-patent, of the said Jacob H. Linville and John L. Piper, (except as aforesaid,) were, prior to the alleged invention or discovery thereof by the said Jacob H. Linville and John L. Piper, mentioned and described or represented in the following printed publications, or public works; among others, that is to say, in a work entitled "Iron Ship-building, with practical illustrations, by John Grantham, consulting engineer and naval architect, Liverpool. London, John Weale, 59 High Holborn, and St. Mary's, Cambridge, 1858;" and more especially on pages 51 and 52, as well as other pages of said work.

Also in a work entitled, "Iron Ship-building, with practical examples and details, in twenty-four plates, together with text containing description, explanations and general remarks for the use of ship-owners and ship-builders, by John Grantham, C. E., consulting engineer and naval architect, Liverpool." Published in London, England, by John

Weale, 59 High Holborn, and St. Mary's, Cambridge, 1858, particularly plate No. 8, Figs. 4, 5, 6, 7, 8 and 9 of said work.

11 Also in a work entitled, "Tubular and other Iron Girder Bridges, particularly describing the Britannia and Conway Tubular Bridges, with a sketch of iron bridges and illustrations of the application of malleable iron to the art of bridge-making, with wood engravings, by G. Drysdale Dempsey, C. E." Published in London, by John Weale, Architectural Library, 59 High Holborn, England; 1850. See particularly pages 25 and 131, as well as other parts of the same.

Also in a work entitled, "The Construction of Wrought-Iron Bridges, embracing the practical application of the principles of mechanics to wrought-iron girder-work, by John Herbert Latham, M. A., civil engineer, with numerous detail plates." Published at Cambridge, England, by MacMillan & Co., and 23 Henrietta Street, Covent Garden, London, 1858. See particularly plate 1, Figs. 1, 2, and 4; also, plate 5, Fig. 21, and other illustrations.

Also, in a work entitled "The Britannia and Conway Tubular Bridges, with general inquiries on beams and on the properties of materials used in construction, by Edwin Clark, resident engineer. Published with the sanction and under the supervision of Robert Stephenson, in two volumes—with plates, in folio." Published in London, England, for the author, by Day & Son, Gate Street, Lincolns-Inn Fields; and John Weale, 59 High Holborn, 1850. Particularly volume 2, pages 611 and 612, and other parts of the same work.

Also, in a work entitled "A complete treatise on Cast and Wrought Iron Bridge Construction, including iron foundations; in three parts, theoretical, practical, and descriptive. Illustrated by numerous examples, drawn to a large scale, by William Humber." Published in London, England, by E. & F. N. Spon, 16 Bucklesbury, 1861. Vol. 1, particularly page 129—also, plate opposite page 84, marked A, Figs. 4, 5, 6, 8, 9 and 14, and other parts of the same work.

12 Also, in a work entitled "Papers and Practical Illustrations of Public Works of recent construction, both British and American—supplementary to previous publications." Published by John Weale, 59 High Holborn, London, England, 1856. Particularly pages 89 and following, and plates 1 to 10, and other parts of the same work.

And these respondents further answering, say that they deny it to be true, as in said bill alleged, that these respondents are infringing upon the rights of the complainants by using and employing the alleged improvements mentioned and described in said letters-patent in said bill mentioned; on the contrary thereof, these respondents say that their mode of making and constructing bridges, posts, and truss-frames, and the parts and appurtenances thereof is in all substantial and material respects different from that described and claimed in said letters-patent of the said Jacob H. Linville and John L. Piper, (except so far forth as said mode is derived from the prior letters-patent of the said Samuel J. Reeves and George H. Sellers, as hereinbefore mentioned, or from prior publications,) and is in no wise, either in fact or in law, as they are advised, and as they believe, an infringement or a violation of any right validly secured thereby to the said patentees, or vested in the said complainants.

And further answering, these respondents say that they deny it to be true, as in said bill alleged, that the said Jacob H. Linville and John L. Piper were, or that either of them was the first and original inventor of the improvements described and claimed in the said several letters-patent granted to the said Samuel J. Reeves and to the said George H.

Sellers respectively, or that knowledge of said improvements was surreptitiously or otherwise obtained by the said Samuel J. Reeves or the said George H. Sellers from the said Jacob H. Linville and John L. Piper, or from either of them, or that the said several letters-patent of the said Samuel J. Reeves and George H. Sellers respectively, were in any wise obtained in fraud of the rights of said Jacob H. Linville and John L. Piper, or of either of them, or of the said com-

13 plainant, or that the same were obtained with the knowledge of any prior invention of the same by the said Jacob H. Linville and John L. Piper, or of either of them; on the contrary thereof, these respondents, insisting that the allegations in that behalf in said bill contained are too vague, insufficient, and uncertain to be answered unto, and craving the benefit of said objection with like effect as if the same had been made by way of exception, plea, demurrer or otherwise, and reserving unto themselves the benefit and advantage thereof, nevertheless for answer say, that they, the said Samuel J. Reeves and George H. Sellers were and are respectively, the true, original, and first inventors of the improvements described and claimed in the several letters-patent granted to them respectively, in said bill mentioned and referred to; and that said letters-patent respectively were granted in due conformity with law, and are in all respects, as the respondents verily believe, legal and valid letters-patent; and these respondents furthermore say that the said Jacob H. Linville and John L. Piper were and are not, and that neither of them was or is the original and first inventor of the improvements mentioned and described in the said letters-patent respectively, and that knowledge of said improvements, or of any part thereof, was not surreptitiously, or in any other way, manner, or form, derived by them, the said Samuel J. Reeves and George H. Sellers, or by either of them, from the said Jacob H. Linville and John L. Piper, or either of them; and that said letters-patent respectively were not applied for, obtained, or granted in fraud of any rights of said Jacob H. Linville and John L. Piper, or either of them, or with any knowledge or belief by the said Samuel J. Reeves and George H. Sellers, or either of them, of any invention, or claim of invention of said improvements by the said Jacob H. Linville and John L. Piper, or either of them, or any infringement therein, and thereby of any rights of the said Jacob H. Linville and John L. Piper, or either of them.

14 And these respondents, without waiving the objection and reservation above mentioned, for further answer say that they are advised and informed, and that they believe that the letters-patent granted to the said Jacob H. Linville and John L. Piper, bearing date January 14, 1862, do not describe or claim the improvements, or any of them, described and claimed in the subsequent letters-patent, granted respectively to the said Samuel J. Reeves and George H. Sellers; and that the said Jacob H. Linville and John L. Piper had not, and that neither of them had, at the time of the grant of the said last-mentioned letters-patent respectively, invented or discovered said improvements in whole or in part; and respondents further say that the attempt of the said Jacob H. Linville and John L. Piper, in and by their subsequent letters-patent, bearing date October 31, 1865, to appropriate improvements described in the prior patents of said Samuel J. Reeves and George H. Sellers, is fraudulent in law; that the earlier and better title of the said Samuel J. Reeves and George H. Sellers cannot be prejudiced or injuriously affected thereby; and that the granting by the Commissioner of Patents of letters-patent to the said Jacob H. Linville and John L. Piper, for improvements described and

claimed in prior subsisting patents of said Samuel J. Reeves and George H. Sellers respectively, without the declaration of any interference between said parties, or without any notice by the Commissioner of Patents or the said applicants, or either of them, to the said Samuel J. Reeves and George H. Sellers respectively, or without allowing unto them any opportunity to be heard before said Commissioner, was improvident, unauthorized, and contrary to law, and that the letters-patent so granted to the said Jacob H. Linville and John L. Piper were and are for that reason null and void.

And these respondents further answering, say that they believe, and so state, that the knowledge of the said Jacob H. Linville and John L. Piper, touching and concerning the improvements mentioned and described by the said Samuel J. Reeves and George H. Sellers in their
15 respective letters-patent, by means whereof the said Jacob H. Linville and John L. Piper were enabled to describe and include said improvements in their said letters-patent, of October 31, 1865, was obtained and procured by them, the said Jacob H. Linville and John L. Piper, by, through and by means of verbal and written communications from time to time, from the said Samuel J. Reeves and George H. Sellers, which said communications described the nature, construction, and operation of said improvements, so as to enable the said Jacob H. Linville and John L. Piper to put the same in practice, and to describe and include the same in the said letters-patent granted to them October 31, 1865.

And as to so much of the bill as prays relief in respect of the alleged violation of the patent set up by the complainants for the construction of top or upper chords—of a combination of wrought-iron I-shaped beams or channel-bars, or both, connected by wrought-iron plates, so as to form cellular chords of great strength and capacity of resisting either transverse strain or longitudinal compression, and as evidence in support of the averment above stated, that the same was not a novel invention—these defendants here exhibit in schedule A, hereto annexed, copies of the drawings of the same annexed to the patent of October, 1865, relied on by the complainants; and copies of the drawings of a similar upper chord constructed in a manner and applied and used in a manner set forth in said patent, and which are taken from the book above mentioned, called "A Complete Treatise on Cast and Wrought Iron Bridge Construction, including iron foundations. In three parts—theoretical, practical, and descriptive." By Wm. Humber. Published by E. & F. N. Spon, 16 Bucklesbury, London, England, 1861. Vol. I., plate A, Fig. 4.

And these defendants, as to so much of the bill as prays rel
spect of an alleged violation of the patent set up by the complai
the use of bottom chords of thin wrought-iron plates, the eye
at each end, instead of being cut out of a rolled plate a
16 or forged into shape, is upset under strong compres
that by the letters-patent set up by the complainants bea
the 31st of October, 1865, the complainants' assignors claime
tained no more than the grant of the right to use bottom cho
of wrought iron, compressed or moulded into the forms in w
are used as chords. They do not in said patent claim the
right to the use of bottom chords for bridges, nor the use
chords when made in any particular form, nor of any partic
stance or material, nor to the mode of making or forming the
which is to be used as a bottom chord, but only to the exclus
to use as bottom chords particular forms of iron—formed or

particular manner; that is, when not formed by the common method of hammering and welding, but formed by compression.

And as evidence that neither the form of the iron plates to be used as a chord nor the use of such forms of iron plates as chords, was, or was intended to be, claimed by complainants' assignors as a novel invention these defendants annex, in Schedule B, copies of drawings of the iron plates as described in the patent set up by complainants, and in a printed work, entitled "Papers and Practical Illustrations of Public Works of Recent Construction, both British and American," published in London, England, by John Weale, 59 High Holborn, 1856—to wit: of Plate 10, among the drawings of details of the bridge over the Newark Dyke, on the Great Northern Railway, in England, in said work; they also refer to the text on page 90 of the above work, where the following language is used in describing these links: "The lower tie consisted of wrought-iron links 8 feet 6 inches long, of the uniform width of 9 inches, but varying in number and thickness, according to the tensile strain to which each portion was subjected; the abutment portions having each four links of 9 inches by 1 inch, and the centre pieces fourteen links of 9 inches by $\frac{7}{8}$ inch."

"The bearing-pins at all intersections were 5$\frac{1}{2}$ inches diameter, carefully turned, and fitting into bored holes."

17 And they also annex hereto, in schedule C, copies of drawings of the mode of applying the plates as bottom or tension chords in the construction of bridges, in the patent set up by complainants, and in the work above referred to, in plates 5 and 8 of the drawings of details of the bridge over the Newark Dyke.

And as evidence that the use of chords when so made is the only claim made by them in respect to bottom chords for bridges, and that they disclaim the right to any method of making or forming the chords, these defendants refer to the letters-patent granted to the assignors of the complainants in October, 1865, and under which by their bill they claim title, and particularly to the following clauses in the specifications annexed thereto:

We have invented a new and useful improvement in wrought-iron bridges, or other truss frames.

The general arrangement of the parts is similar to that shown in our previous patent, the improvement forming the subject-matter of this invention relating to the following particulars:

3d. The use of bottom chords of thin wrought-iron plates, the eye of which at each end, instead of being cut out of a rolled plate and drilled or forged into shape, is upset under strong compression, so as to give at the eye of the bar a degree of strength equal or superior to that of the bar at any point between the eyes.

The bases of the posts A are connected at their bases longitudinally by the lower chords D, of which four may be placed parallel to each other, on each side of each panel. They are made of thin bars of rolled iron of sufficient depth, and placed on edge so as to support the roadway, and are attached to the bases of the posts by the connecting-pins N, which pass through the hole or eye near the end of these bars. * *

The lower chords D consist of wide thin rolled iron bars with enlarged ends, which are made by upsetting the rolled bars by compressing them into the desired shape in moulds into which the heated iron is forced under immense pressure, thereby increasing the density, toughness and strength of the enlarged ends, and permitting the holes or eyes for the connecting-pins N to be cut out without rendering the transverse sec-

tion at the eye less than that of other parts of the bar, or diminishing the transverse or longitudinal strength of the chord-bar.

We do not claim the upsetting of bars in the manner described,
18 nor any peculiar mode of performing the operation, but merely the use of chord-bars for bridges, the ties of which are thus formed so as to give additional strength to the bar where it is so much needed. * * * * * * * *

What we claim as our invention * * is * * * *

3d. The use for the lower chords of truss frames, of wide and thin rolled bars with enlarged ends, formed by upsetting the iron when heated by compression into moulds of the required shape, for the purpose of increasing the density, toughness, and strength of the eye of the rod, and enlarging the eye without diminishing its transverse section, substantially as hereinbefore described.

And these defendants aver that the said claim and gra
matters in all particulars designed and invented by these de
that the design was conceived by these defendants, and com
to the assignors of the complainants with information th
patent were intended to be applied for, more than two years
assignors of the complainants obtained their said patent;
of the objects for which the invented article was intended t
was, and is, precisely that use [claimed by complainants' as
their said patent as theirs exclusively; that this intended
thing to be made under the projected invention of the defen
also then communicated by defendants to complainants' assig
complainants' assignors' method was perfected, and the iron pl
and these were ordered by the complainants' assignors, or on
at the instance of defendant, S. J. Reeves, in 1863; and
made by defendants and sold and delivered to complainants'
or one of them, to be used as bottom chords in the manner de
the assignors of the complainants' letters-patent as early as A
and were so used by them, as these defendants believe, long b
applied for and obtained the said letters-patent, under which t
their title; and that the letters-patent set up by the compl
this particular is a fraudulent attempt to secure to themselves
sive right to one of the uses of the manufactured article made
defendants under their patent; which use was, by the com
assignors, known to be one use, to or for which the ar
19 ented and made by defendants was intended and was a
and which intention was communicated to the compla
signors by the defendants.

As evidence thereof these defendants aver and charge—that on the first of January, 1863, the complainants' assignor, J. H. Linville, wrote the defendant, S. J. Reeves, a letter, in which he said:

DEAR SIR: In the construction of the channel span, Steubenville iron bridge, the following bill of iron will be required, viz:

16 bars 2¾″ sq. 33′ 6″ long 9,926

[Then follows a long list of similar iron bars of various dimensions.]

The following bill of hammered iron will also be required:

Bill of lower chords.

No. of pieces.	Size of chords	Width and thickness of ends.	Length to the centre of eye.	Total length.	
96	$8\frac{1}{2} \times \frac{7}{8}$	13×1	$12 \times 2\frac{1}{2}$	$13.\ 4\frac{1}{2}$	The iron is to be of the best quality anthracite, well refined, tough and fibrous, free from flaws and defects, and drawn to a template, except the rounding of the ends, which may be roughly sheared. Tensile strength 65,000 lbs per sq. inch.
32	$9 \times \frac{7}{8}$	$13\frac{1}{2} \times 1$	$12 \times 2\frac{1}{2}$	$13.\ 5\frac{1}{2}$	
48	9×1	$13\frac{1}{2} \times 1\frac{1}{8}$	$12 \times 2\frac{1}{2}$	$13.\ 5\frac{1}{2}$	
32	$9 \times 1\frac{1}{8}$	$13\frac{1}{2} \times 1\frac{1}{4}$	$12 \times 2\frac{1}{2}$	$13.\ 5\frac{1}{2}$	
16	$9 \times 1\frac{1}{4}$	$13\frac{1}{2} \times 1\frac{3}{8}$	$12 \times 2\frac{1}{2}$	$13.\ 5\frac{1}{2}$	
32	$9\frac{1}{2} \times 1\frac{1}{4}$	$14 \times 1\frac{3}{8}$	$12 \times 2\frac{1}{2}$	$13.\ 5\frac{1}{2}$	
32	$9\frac{1}{2} \times 1\frac{3}{8}$	$14 \times 1\frac{1}{2}$	$12 \times 2\frac{1}{2}$	$13.\ 5\frac{1}{2}$	
32	$9\frac{1}{2} \times 1\frac{1}{2}$	$14 \times 1\frac{5}{8}$	$12 \times 2\frac{1}{2}$	$13.\ 5\frac{1}{2}$	
48	$10 \times 1\frac{1}{4}$	$14\frac{1}{2} \times 1\frac{3}{8}$	$12 \times 2\frac{1}{2}$	$13.\ 6\frac{1}{2}$	
48	$10 \times 1\frac{3}{8}$	$14\frac{1}{2} \times 1\frac{1}{2}$	$12 \times 2\frac{1}{2}$	$13.\ 6\frac{1}{2}$	

20 External corners of ends to be sheared.

Please send us a bid on the foregoing, soon as convenient. Delivered on P. R. R. Co.'s cars, Philadelphia. Order to be filled by May 1, 1863.

Respectfully, yours,

(Signed) J. H. LINVILLE.

To which said defendant replied:

OFFICE OF THE PHOENIX IRON COMPANY,
Philadelphia, January 5, 1863.

J. H. LINVILLE, ESQ., *Resident Engineer, P. R. R., Altoona.*

DEAR SIR: Your favor of the 1st instant came duly to hand, with specification of about 80 tons long bridge iron, and a lot of hammered iron for links.

This is a very difficult lot of iron to make, but still we have done it for others, and can do it for you. The price for the rolled iron would be five cents per pound, cash, on your cars at our works. The quality will be equal to the specification.

Respecting the links, I would say that we have designed a method of making them of rolled iron, which we think much better than hammered bars, as well as cheaper. We have had this kind of work in contemplation for some time, but have postponed the necessary preparations on account of other pressing engagements. If you can wait a few days, I think I shall be able to make you a bid for all your link bars.

I saw a few days ago a much larger specification of bar iron, which I presumed to have come from you, say some 375 tons additional. Would like to bid for that also.

Yours, very truly,

SAMUEL J. REEVES,
Vice-President.

And said complainant, in reply, said:

"S. J. REEVES, ESQ., *Vice-President Phœnix Iron Co.:*

"DEAR SIR: Your favor of yesterday came duly to hand. * * *. I have always believed that there could be some cheaper process than hammering devised for making eye bars or links. Since I am designing several long spans in which I shall use them, I am pleased that you have taken up the subject. I expect to visit you in a few days.

"Yours, respectfully,

(Signed) "J. H. LINVILLE."

And further by telegraph, as follows:

"ALTOONA, *January* 19, 1866.

"SAMUEL J. REEVES, 410 *Walnut Street:*

"I have been prevented from going to city—pressure of business.

"Can you give me your ideas by letter about rolling the links for
21 bridges? Send a sketch and such description as will enable me to judge whether they will answer our purpose. If I know soon by train to-morrow morning, I may use them in a number of other spans. The price at which you can furnish them, and time by which they could be furnished, would determine whether I could use them.

(Signed) "J. H. LINVILLE."

To which said defendant replied:

"PHILADELPHIA, *January* 19, 1863.

"J. H. LINVILLE, ESQ., *C. E., Altoona, Pa.:*

"DEAR SIR: Your despatch of this morning with inquiry about the price of links, &c., is duly to hand.

"Respecting the plan upon which we propose to make links for bridges, I beg to state that, inasmuch as we are preparing drawings and specifications for letters-patent, you will not feel offended if I ask you, for the present, to excuse me from going into the details. We are so perfectly satisfied that it can be accomplished, that I do not hesitate to make it a condition of the offer to supply, that if you do not consider them entirely satisfactory, after they are made, you will have the privilege of throwing them on our hands. The metal about the eyes will, I think, be both denser and stronger for equal sections than the remaining part of the bar. On one point I will speak for your satisfaction, that is, there is no cutting and no welding done in the process of forming the eyes. In regard to price we propose to charge one cent per pound extra on the bar used, and each bar will be required to be cut about one foot longer than the finished link. We shall be able to make them of any required dimensions, say from four to twelve inches wide, and any lengths. The price named applies to bars not shorter than ten feet. The thickness of the metal in the eye will be increased only a trifle above the normal thickness of the bar in its other part.

"As to the time when we could engage to make deliveries, I think we can promise to furnish them as soon as you will require them, certainly much sooner than you can obtain them from the forges. After rolling the bars there will be but little time lost in finishing the links. I hope you will give us the order, as I feel the most perfect assurance that you will be satisfied with the work. I have no hesitation in offering to guarantee that the links will be as strong and, at least, as sound as any you can procure from the forges. For the sake of making the price fixed and absolute, I will say that we will furnish them of undoubted quality, and subject to your approval and inspection, for six cents per lb. cash, F. O. B. cars at the works.

"Very truly, yours,

"SAMUEL J. REEVES,
"*Vice-President.*"

22 After this, said Linville having announced his intention did call on said defendant, and examined into the proposed scheme which said defendants were then perfecting. And thereupon, after having acquired a knowledge of their design to form or manufacture links

which were adapted to be used as lower or tension chords in the construction of bridges, on the new method for which letters-patent were granted to one of the defendants on the 29th March, 1864, wrote the defendant, S. J. Reeves, the following letter, with the annexed specification:

"RESIDENT ENGINEER'S OFFICE, MIDDLE DIVISION,
"*Altoona, Pa., January* 28, 1863.

"SAMUEL J. REEVES, ESQ., *Vice-President Phœnix Iron Co.:*

"DEAR SIR: Being satisfied from the explanations and assurances given in your letter of the 19th inst., and from my interview with the secretary and superintendent of your company, that the chord links for Steubenville bridge can be made from rolled iron, with ends formed according to your process, I send herewith an order, No. 489, for the same. It will be distnctly understood that the links will be formed according to the drawings herewith forwarded—or with only such slight variations as we may hereafter agree upon. The iron must be of undoubted quality and superior workmanship, and possess a tensile strength of sixty thousand (60,000) pounds per square inch of transverse sectional area. It is understood that the enlarged ends of the links are to be finished, ready for drilling, excepting any slight reduction of thickness, not to exceed one-sixteenth (1-16) of an inch.

"For links furnished as above we agree to pay at the rate of six (6) cents per pound free on board cars, at your works. As early as practicable, a specimen bar should be forwarded me for inspection. The links will all be required previous to June 1, 1863. Please acknowledge receipt of order and acceptance of terms.

"Very respectfully, yours,

"J. H. LINVILLE, *R. E.*

"No. 489.

"RESIDENT ENGINEER'S OFFICE, *Altoona, Jan.* 28, 1863.

"To the Phœnix Iron Company:

"You will please deliver the following on account of the Pennsylvania Railroad Company, and forward the bill immediately to the undersigned.

23	"Number of pieces.	Width and thickness of bar.	Width at A. B.	Length centre to centre of eye.
	"96	$9 \times \frac{7}{8}$	1.2	12.3
	"32	9×1	1.2	12.3
	"32	$9\frac{1}{2} \times 1$	$1.2\frac{1}{2}$	12.3
	"32	$9\frac{1}{2} \times 1\frac{1}{8}$	$1.2\frac{1}{2}$	12.3
	"32	$10 \times 1\frac{1}{8}$	1.3	12.3
	"32	$10 \times 1\frac{1}{8}$	1.3	12.3
	"32	$10 \times 1\frac{1}{4}$	1.3	12.3
	"32	$10 \times 1\frac{1}{2}$	1.3	12.3
	"48	$10\frac{1}{2} \times 1\frac{1}{2}$	$1.3\frac{1}{2}$	12.3
	"48	$10\frac{1}{2} \times 1\frac{3}{4}$	$1.3\frac{1}{2}$	12.3

"NOTICE.

☞ "No agent or foreman of the Pennsylvania Railroad Company is allowed to contract for the company, except by order of the general superintendent, the division superintendents, or the resident engineers

in charge of road repairs. All other debts contracted by persons in the employ of the company, must be on the individual responsibility of the person who contracts them.

"Mark on your bill the number of this order."

And the following memorandum was entered on defendant's order-book when the foregoing order was received :

"PENNSYLVANIA RAILROAD COMPANY,
"*J. H. Linville, Resident Engineer, Altoona, Pa.*

"Per order 489 on file. (See J. H. Linville's letter, Jan. 28, 1863, copy of which was sent to the works. Ship per Penn. R. R.

"All wanted previous to June 1, 1863. As early as practicable a specimen bar is to be forwarded to him for inspection.

"Freight to be charged to Steubenville Bridge Co. (See J. H. Linville's letter, Jan. 29.)

"Mark, 'Care of J. H. Linville, Altoona, Pa.'

		Width at A. B.	Length centre to centre of eye.
"96 pieces.	9 × $\frac{7}{8}$	1.2	12.3
"32 "	9 ×1	1.2	12.3
"32 "	9$\frac{1}{2}$×1	1.2$\frac{1}{2}$	12.3
"32 "	9$\frac{1}{2}$×1$\frac{1}{4}$	1.2$\frac{1}{2}$	12.2
"32 "	10 ×1$\frac{1}{4}$	1.3	12.3
"32 "	10 ×1$\frac{3}{8}$	1.3	12.3
"32 "	10 ×1$\frac{1}{2}$	1.3	12.3
"32 "	10 ×1$\frac{5}{8}$	1.3	12.3
"48 "	10$\frac{1}{2}$×1$\frac{5}{8}$	1.3$\frac{1}{2}$	12.3
"48 "	10$\frac{1}{2}$×1$\frac{3}{4}$	1.3$\frac{1}{2}$	12.3

24 "The enlarged ends of the links are to be finished ready for drilling, excepting any slight reduction of thickness, not to exceed one-sixteenth of an inch.

"Chord links, Steubenville Bridge.

"NOTE.—Describe circle of pin-hole, with radius 2$\frac{1}{4}$". Erect a perpendicular through center. From points in this perpendicular on opposite side of pin-hole, with a radius equal to dia. of pin-hole, plus half width of chord +$\frac{1}{4}$; describe the circular ends, and with similar radii make the reverse curves terminate in the sides of the chord which will be tangential.

"32 of the 96 (9+$\frac{7}{8}$ 14" wide at the eye, 12'.3" center to center of eye) pieces may be upset at one end, only leaving the other end with parallel sides as it comes from the rolls. See J. H. Linville's letter on file, May 17, 1863."

On the 17th February, 1863, the defendant, George H. Sellers, wrote the assignor of the complainant, J. L. Piper, as follows :

The links we can make by the 15th of May. If you can substitute 7$\frac{1}{2}$" iron instead of 7", could make them somewhat sooner. Costs 6 cents per lb.

And again, on the 24th September, 1863:

I am sorry to ask your further indulgence on the link order, but owing to the scarcity of good moulders, together with the loss of two of
25 our heavy pieces in casting required for our machine, we have been much disappointed and delayed. On Monday we expect to cast the two heaviest pieces yet to make, which, if successful, we will be able to get our machine together in all of next month, when we can

finish up the links as rapidly as Mr. Piper will wish. Hoping you will not be seriously inconvenienced by the delay, and that you will be amply compensated by their quality, I am yours, respectfully,

GEO. H. SELLERS,
General Superintendent.

And again, on the 7th of December, 1863:

The machinery necessary for making the links is nearly completed, and our workmen are briskly engaged erecting it.

Our experimental trial made early in the season proved exactly what I had predicted before the trial, which was, that our power was too light and slow. To make links successfully, it is necessary to have unlimited power operating upon the bar rapidly, so that it may be formed in less than a minute after its removal from the furnace. The machine we are constructing consists of an hydraulic accumulator, from which the power is conveyed to a hydraulic press exerting, if desired, a force of 300 tons, which can be put in motion as rapidly as you may desire, and checked instantaneously at any point.

This machine is necessarily very heavy, will weigh nearly 100 tons. I feel now very confident of success, and I hope to have the pleasure of showing the same to you when in operation.

The foreman who has charge of putting up the machine thinks he can have it put up ready for operation in 3 weeks after it is set up. It will probably take 1 week to make all of the connections.

I know the delay is a serious loss to you. At the same time I assure you I am sparing no pains or time to hurry the machinery forward to completion, and am satisfied that we will be able to give you the iron in the shape of drawing furnished, and I think entirely satisfactory as to finish. The difficulty of procuring workmen, with the inability to get any work done by other parties, compelling us to do all ourselves (to do which have worked our hands day and night) is the only excuse I can offer for the delay in finishing your work.

On the 28th March, 1864, said Linville wrote the defendant Reeves as follows:

PITTSBURGH, *March* 18, 1864.

SAMUEL J. REEVES, Esq., *Vice-President Phœnix Iron Co.:*

DEAR SIR: The work on Steubenville Bridge has now reached a point where serious inconvenience, delay, and consequent loss to the company must ensue unless you can commence the delivery of the lower chord-links.

It will require at least two months to drill the entire lot of chords,
26 and hence the necessity of having a portion of the chords delivered without delay, in order that the process of drilling may be commenced. Please state definitely as possible the earliest time at which you can commence delivering the chords.

Very respectfully,

J. H. LINVILLE.

And again, on the 21st March, 1864, after making in a letter some inquiry respecting another subject, added:

I believe with the upset chord-bars and the tubular wrought iron, a combination can be effected that will surpass anything yet attempted in iron-bridge building.

Thus distinctly recognizing that the known object for which the article

being manufactured by the defendants, and called by them links, was a chord, and was ordered by him to be made and used for that purpose.

On the 18th April, 1864, and from thence at intervals in May, July, and August to the 15th September, 1864, these links for the lower chord of a bridge were shipped to complainants' assignors under said order, and were used by them in the construction of a bridge at Steubenville, Ohio.

Without this, that there is any other cause, matter, or thing in the said complainants' said bill of complaint contained, not hereby and herein well and sufficiently answered and confessed, or traversed and denied to be true, as these defendants tender themselves ready to prove, as the court may direct; whereupon the respondents pray to be hence dismissed, with their reasonable costs and charges in this behalf most wrongfully and unjustly incurred.

And they will ever pray, etc.

SAM'L J. REEVES.
GEO. H. SELLERS. [SEAL.]

R. C. M'MURTRIE,
FURMAN SHEPPARD,
GEORGE HARDING,
For Defendants.

27 Samuel J. Reeves & George H. Sellers, being duly affirmed. sa*ith* that the facts stated in the foregoing answer, so far as stated from *his* own knowledge, are true, and so far as stated from the information of others, *he* believes them to be true.

SAM'L J. REEVES.
GEO. H. SELLERS.

Affirmed and subscribed before me this 23rd day of May, 1868.
W. W. DOUGHERTY,
Alderman.

28 And afterwards, to wit, on the third day of April, in the year 1871, the following agreement was filed:

It is agreed that a replication shall be deemed to have been filed on the 7th May, 1868, and that the app't of John Rodgers as Com'r to take testimony should be considered as made.

29 And afterwards, to wit, on the fifteenth day of April, in the year last aforesaid, the examiner comes and files his report of testimony which, being read, is as follows, to wit:

30 Circuit Court of the United States, eastern district of Pennsylvania.

KEYSTONE BRIDGE COMPANY *vs.* THE PHŒNIX IRON COMPANY. } October sessions, 1867, No. 45.

Depositions of witnesses produced, sworn, and examined, on the part of the complainant, before the examiner appointed in said cause, on this twenty-second day of September, 1869.

C. B. Collier, esq., attending as counsel for complainant, and R. C. McMurtie, esq., for the defendant.

EDWARD E. CRUEGER, being first duly cautioned and solemnly sworn, deposeth and saith as follows:

Question 1. State your name, your age, your place of residence, and your occupation.

Answer. Edward E. Crueger; thirty-nine years of age, or thereabouts; residence, Altoona, Pa.; my occupation a draughtsman, in employ of Pennsylvania Railroad Company.

Q. 2. How long have you been so engaged?

A. Since June, 1858.

Q. 3. Are you acquainted with Jacob H. Linville and John L. Piper, and if so, for how long have you known them?

A. I am acquainted with both parties, and have known Mr. Linville since June or July, 1858, and Mr. Piper since August, 1858.

31 Q. 4. Have you read, and do you understand, the letters-patent issued to Jacob H. Linville and John L. Piper, dated January 14th, 1862, No. 34183, entitled "Improvement in Iron Truss Bridges?"

A. I have read it, and I understand it, too.

Q. 5. What do you know, if anything, relative to the making of the inventions described in said patent—particularly as to the date of such inventions, and the circumstances under which the same were made, and give the sources of such knowledge as you may have on the subject.

A. In about the years 1859 or 1860, I heard that the Pennsylvania Railroad Company were going to build a bridge across the Schuylkill River, and I understood from Mr. Linville that proposals were to be received for building the bridge. I prepared, under the instructions of Mr. Linville, quite a number of drawings. The drawings which I prepared at the time, sometime in October, 1860, probably earlier, until the bridge was completed in the shops. This is the first drawing I made (marked A, and by the examiner, J. R., 1.) This is the side of the elevation for a truss bridge; that is the top drawing; the middle drawing is a plan of a bottom chord and of a top chord. The figure at bottom of drawing, called end-view, represents the portal of a bridge. The smaller drawing to the right represents a cross-section. The drawing at the extreme right, below, represents a piece of the bottom chord, or links; and the drawing on the extreme left is a plan of a bolt. The second drawing (marked B, and by the examiner, J. R., 2) represents the upper figure, a pivot-span of a bridge, with wrought-iron bottom and top chord, and wrought-iron posts, and flat wrought-iron base. On the right of the drawing, the middle one represents the plan of the bottom chord, of wrought iron, cast-iron struts, and wrought-iron tie-rods, with cast-iron rings. On the right lower corner is a section and elevation of pivot. In the centre, below, is a plan of the turn-table for the pivot. On the left, in the middle, is a cross-section of the bridge,

32 consisting of wrought-iron swelled posts, wrought-iron bottom and top chords, cast-iron struts, the posts being sprung apart by ferrules, and held together by rivets. On the lower left corner of drawing is a detail of the post, and a detail showing the connection between the upper and lower chord and the cross-section of the post. The third drawing (marked C, and by the examiner, J. R., 3) represents—this drawing shows the elevation and section of a wrought-iron post, with cast-iron base and capital. The posts on this drawing consisted of two semi-octagonal wrought-iron pieces or bars of iron, sprung apart by cast-iron spreading-pieces. They were held in place by rivets through the whole post. The base and capital in this post are of cast iron. The two first drawings (A and B) I finished in November, 1860. The last drawing (C) I finished about January, 1861. The first plan (A) was either sent or taken by Mr. Linville to Mr. Thomson, the president of the Pennsylvania Railroad. Mr. Linville came and told me that Mr. Thomson had adopted the general plan of A, with the exception of the posts; the posts in A being of cast iron. B was sul-

mitted to Mr. Thomson at the same time as plan A; in fact, all the drawings were submitted at same time to him. Mr. Thomson wanted a wrought-iron post. I do not mean that the drawing C was submitted to Mr. Thomson. I then had to get up the working drawings for the bridge, and under Mr. Linville's instructions. Mr. Linville showed and sketched for me different forms of wrought-iron bars or pieces for posts; any number of them, and all shapes—of angle-iron, of T-iron, of round iron, of oval iron. I can't remember the number of shapes he gave me; they were too many. He had two pieces in some posts, and four in others. Finally he (Linville) rejected all the other pieces, except those pieces which we employed at the Schuylkill bridge. As the other pieces which Mr. Linville sketched were impracticable for his purpose, he adopted that post, composed of two semi-octagonal pieces, in the Schuylkill bridge. The inventions, as shown in the patent referred to, are also shown in the exhibits.

Q. 6. Will you please describe, more particularly, the other forms of wrought-iron pieces for posts, which you say were sketched by
33 Mr. Linville, and state what, if anything, was shown in said sketches as to the manner of fastening together such posts?

(Mr. McMurtrie objects to question, because it is seeking to obtain secondary evidence without producing the matter or primary evidence, to wit, the documents, the contents of which the witness proposes to prove.)

A. He made some round, without flanges; he made round, with flanges—that is, not circular—half-round; each piece was half-circle; he made ovals, or half-ovals rather, I believe with and without flanges, too; he made them semi-octagonal, with and without flanges. Those pieces, with flanges, Mr. Linville spoke of fastening them together with bolts and rivets; and where he wanted to spread them he could do so by intervening pieces, or by ferrules. He spoke of that to me explicitly.

Q. 7. Of what number of pieces or parts were the different forms of posts—referred to in your last answer as sketched by Mr. Linville—composed?

A. These were composed out of two pieces and out of four pieces. He made the post of four pieces of angle-iron, as shown in Exhibit B, and out of four pieces of round iron.

Q. 8. Do you mean by "round iron," solid, round bars, or hollow shells of circular shape, and did they have flanges or not?

A. They were not solid; they were just mere shells, and some of them had not flanges; others had.

Q. 9. Will you explain what you mean by the words "ovals, or half-ovals, rather," in answer to the sixth question; whether or not such forms of posts were made of two, or more than two, pieces of that shape?

A. The ovals were, as often occurs; were probably sketched by myself on the same piece of paper on which Mr. Linville made his sketches; they were out of two pieces—half-ovals each; such posts were not made.

Q. 10. Will you please state why the bridge on the Schuylkill was not constructed—as to its posts—according to the sketches which
34 you have stated were made by Mr. Linville; in other words, why the posts of said bridge were made without flanges?

A. Mr. Thomson had adopted the plan A—the general appearance of the bridge on plan A; and Mr. Linville told me frequently that he wished to preserve the same architectural effect, and he made the posts in appearance the same as plan A, with the exception of the wrought iron; this to be wrought iron instead of cast iron. As the posts on

Schuylkill bridge had cast iron base and capital, we had to mould the bases and capitals around the posts. Mr. Linville objected to flanges; furthermore, he objected to flanges on account that the main carrying-rods would not pass by the posts without either cutting away the flanges or making the base and capital wider. The cutting away of flanges, which I suggested to Mr. Linville, he objected to, or telling me that it made the posts too weak.

Q. 11. When this objection was urged by Mr. Linville, what form of post was under consideration, and of how many pieces was it proposed to be constructed?

A. I believe it was two pieces, or may be four; I don't recollect. They were either half or quarter sections of circle.

Q. 12. Will you please examine the letters-patent No. 35582, issued to Samuel J. Reeves, June 17th, 1862, and state wherein, if at all, the posts therein described, and shown in the drawings thereto attached, differ from the posts which you say were sketched by Mr. Linville at the time referred to?

A. I think this is the same as what Mr. Linville had. I only see one difference here. The posts are not spread in the section here; there are no ferrules used. Mr. Linville spoke of spreading his posts. I do believe that is just exactly what Mr. Linville has in his letters-patent, with this exception, that is, binding them by bands firmly to the filling or distant pieces. I can't see that in Mr. Reeves's patent—Figure 4 in Mr. Reeves's patent; Mr. Linville never made anything like that.

Q. 13. What difference, if any, is there between the form of posts shown in Figure 2, in the patent of Mr. Reeves, and those sketched by Mr. Linville at the time referred to by you?

35 A. Not any that I see; except Mr. Linville, when he showed me anything, or sketched anything for me, he put ferrules between them; when he showed me anything, he sketched everything invariably for me.

Q. 14. What was said by Mr. Linville at the time, if anything, relative to the manner of making these posts, that is, as to preparing the iron?

A. Mr. Linville told me that we had to make posts of various thicknesses of iron, and that could be effected by elevating or lowering the rolls. I believe the Schuylhill bridge is built that way—of various thicknesses.

Q. 15. Will you please state, as nearly as you can, the time when these sketches of different forms of posts were made by Mr. Linville?

A. They were made during November and December, 1860.

Q. 16. Were the sketches so made by Mr. Linville, as described by you, sufficient or insufficient to have enabled a person of ordinary skill, in the construction of bridge-iron and bridges, to have made posts of that character?

A. They were sufficient.

Q. 17. What do you know, if anything, relative to the participation of John L. Piper in the invention of these improvements?

A. Mr. Piper was very frequently in our office, and more so at that time while I was at work on those plans; and I heard Mr. Linville and Mr. Piper frequently talking about different shapes for wrought-iron posts. I saw Mr. Piper, as well as Mr. Linville, make sketches for posts and other parts of the bridge.

(The counsel for the Keystone Bridge Company produces a model,

marked Exhibit D, and identified by the endorsement, by the examiner attached thereto, and offers the same in evidence.)

Q. 18. Will you please look at the model, Exhibit D, and state wherein, if at all, the same is like, or unlike, so far as the shaft of the post is concerned, the sketches which you have stated were made by Mr. Linville, in 1860?

A. I just see one difference in that model; that is, the four
36 parts, of which the shaft consists, are of a different section from those made by Mr. Linville; otherwise, I do not see any difference in the shaft only.

Q. 19. Will you explain, minutely, the difference between the several sections of this model and those so sketched by Mr. Linville?

A. That is a very hard matter. In Mr. Linville's sketches the sections were half round, semi-octagonal, of angle iron—which last were, as shown in Plan B, put together in shape of a post, viz., the angles of the irons pointing towards the center of the post. In this section of this model, the iron, or the pieces composing the shaft of the post, are of such a shape that it will take me a good while to describe. Well, I am too dumb. I do not know what that form is called (referring to Exhibit B.)

Q. 20. Did the sections of said sketches, where four pieces were employed, differ from the sections of Exhibit D, except in shape? and if so, please describe any other difference.

(Mr. McMurtrie objects, as leading, and as particularly objectionable after what has occurred.)

A. The shape of the different pieces composing the sections of sketches differ from the sections of the pieces in this model; in no other way.

Cross-examination:

X-Q. 21. What bridges have you known, built since that Schuykill bridge that you have referred to was built, in which were used posts composed of two pieces, upon the plan that was adopted in that bridge?

A. I don't remember of any. Mr. Linville had another draughtsman after me.

X-Q. 22. You have said, in your answer to the eighth question, something about posts composed of four pieces of round iron; where did you ever see or know of such a post used?

A. I made a sketch myself, after which a little rough model was made for Mr. Linville, and with which he made tests. This, I believe, was in 1860; probably in September, or a little later.

37 X-Q. 23. Did you see that little rough model that he made the tests with?

A. Yes; had it, before and after the time, in my hands.

X-Q. 24. What was the diameter of each of the round pieces of iron that composed the post?

A. Probably a quarter of an inch.

X Q. 25. Were each of these round pieces of iron hollow or solid?

A. I believe they were hollow; I think they were gas-pipes.

X-Q. 26. What is the difference between the forms of the pieces composing a column in Reeves's patent, of June, 1862, and the forms for the same object in Linville's patent, in January, 1862?

A. In Linville's patent the pieces composing the post are semi-octagonal, and in Reeves's patent they are quarter-circles, and straight; straight belongs to another shape. Quarter-circles are shown in Figure 2, and straight in Figure 4.

X Q. 27. What other differences do you observe between those

patents, in reference to those pieces, either in the forms as exhibited in the drawings, or as described in the specifications?

A. In regard to the forms, I spoke before. In the drawings of the two letters-patent, is that difference that the section in Mr. Linville's patent has no flanges; whereas in Mr. Reeves's letters-patent the sections have flanges. In the general, as I understand the descriptions, I don't see any difference.

X-Q. 28. What is the difference between these sections, as shown in Exhibit D, and those described in Linville's patent, of January, 1862?

A. As I have before remarked, the section in Mr. Linville's letters-patent is of semi-octagonal shape; whereas, in Exhibit D, the shape of section of pieces composing the shaft of column is unknown to me—that is to say, I do not know by what word to describe that form.

X-Q. 29. What is the difference between the specification in Linville's patent, of 1862, and Exhibit D, as to the number of sections to be employed in composing a column?

38 A. The section of Exhibit D is composed of four pieces, and Mr. Linville's patent calls for two.

X-Q. 30. Is there, therefore, not these distinctions in reference to these sections between Mr. Linville's patent of 1862, on the one hand, and Mr. Reeves's patent and Exhibit D on the other, viz, that the former is composed of two pieces, without flanges, fastened together by rivets through the column; the latter, of three or more pieces, with flanges, and fastened together by rivets through the flanges?

A. Yes, there is.

X-Q. 31. In your judgment, are these differences, or either of them, improvements upon the method or form of post-pieces, as set forth in Mr. Linville's patent of 1862?

A. I do not know whether I would consider them improvements upon the method aforesaid; some persons would; I don't know that I would.

X-Q. 32. Examine the patent to Linville and Piper, No. 50723, October 31, 1865, so far as the same relates to the number of pieces composing a column, the mode of fastening through flanges, and state in what respect the claims on those heads are improvements upon their former patent; if, in your opinion, the same things, as claimed in Mr. Reeves's patent of 1862, are not improvements?

A. I do not know that this would be an improvement on the first of Mr. Linville's patent. There are some differences and some additions in this second patent, but I would not call them improvements.

Re-examination:

Q. 33. Calling your attention to the section of posts, as shown in Figure 9 of the patent of Linville and Piper, of October 31, 1865, will you please state wherein, if at all, the same differs from the sketches made by Mr. Linville in 1860, as testified to by you?

A. It does not differ in any other respect, except the sections of the four parts composing the posts. In the sketches made by Mr.
39 Linville, the parts composing the posts were of part of a circle, or they were of angle-iron; whereas, in Figure 9, the section of the parts are of an irregular shape.

Q. 34. When they were not made of "angle-iron," but of "part of a circle," of how many parts were the posts to be composed?

(Mr. McMurtrie objects, as before, for reason given as above.)

A. Of two and four parts.

EDWARD E. CRUEGER.

Sworn and subscribed before me this 22d September, 1869.

JOHN RODGERS,
Examiner.

FRIDAY, *September 24th*, 1869.

Met pursuant to adjournment. Present: C. B. Collier, esq, for complainant; R. C. McMurtrie, esq., for defendant.

JACOB SZINK, being duly cautioned and solemnly sworn, deposeth and saith:

Question 1. State your age, your place of residence, and your occupation.

Answer. I am forty-four years old; place of residence, Altoona, Blair County, Pennsylvania; by occupation, blacksmith; foreman of blacksmith shop No. 1, of Pennsylvania Railroad Company.

Q. 2. How long have you resided at Altoona?

A. I went there in 1852.

Q. 3. Have you ever made eye bars, such as are used as lower chords of railroad bridges?

A. Yes, sir.

Q. 4. How were they first made by you, and when?

A. They were made out of flat bars, by turning over and welding down to form the eye; they were also made by jumping pieces on the side; also, in a die; also, in a machine; first made in 1861, in the machine.

Q. 5. Please describe the machine, and state under whose directions it was made, or by what name the process was known.

A. The first machine we made was a die, bound together by two clamps, in which we laid the bar, heated, and drew it up at the end by a follower-plate, to fill up the recess in the casting of the die, which formed the eye of the bar; after that we made a machine larger, on the same principle as the former casting. This machine was made as directed by Mr. Piper, with the addition of the box and strap-hinges, which made it more convenient to work. It was also drove up by a follower, in the first place with sledges; then there was a screw applied; next was a knuckle-joint applied, to work more effectual and give more power; the screw and the sledges were not quick enough. Both these machines were made under direction of Mr. Piper. The process was known as an upsetting machine, to form eyes for bridges. On the first machine Mr. Piper was experimenting; on the small one he found it was a success, and he made a large one. The first one was made in December, 1861, and between that and July, 1862, he had the other made.

(Counsel for the Keystone Bridge Company produces and introduces a model, marked Keystone Exhibit E.)

Q. 6. Please look at Exhibit E, and state what the same represents.

A. This model represents John L. Piper's upsetting machine; the die just as Piper's—the machine I have been speaking about; that is this die, just exactly; the follower also. The only difference I see is, the strap-hinges clamp the box together. We had strap-hinges on the large machine. The balance of this machine is just like the other; I can see no other difference.

Q. 7. Did you see the machines which you say were constructed under Mr. Piper's directions, in 1861 and 1862, in operation; and, if so, how did they work?

A. I saw them in operation; they worked as I stated before; we made eye bars in them; the eye-bars were so good that the

superintendent of the Pennsylvania Railroad, Mr. Lewis, was satisfied with them; that they were better than the ones that were welded.

Q. 8. State where the machines referred to by you now are, if you know.

A. It was taken out of my shop and placed in the bridge shop, where they could attach power to it; it remains there now. I suppose about a year ago that I saw it there.

Q. 9. Has the machine, which you say was constructed in 1862, been in use up to the time when you last saw it—say about a year ago?

A. It was in use on the Steubenville bridge, making iron; I mean upsetting iron for that bridge. This was in 1864, I guess; at the time that I came out of the Army; they were then working at it, and working the machine for iron on that bridge.

Cross-examination:

X-Q. 10. How many machines have there been constructed for making links, by the upsetting process, for the Pennsylvania Railroad Company, of this character?

A. I do not know of any made for the Railroad Company.

X-Q. 11. How many have there been constructed or used in their shops for anybody?

A. This one. The first one I don't count, as it was only a die, to try the experiment to see if it could be done; that is the way I understood when I done it.

X-Q. 12. Do you know whether that machine is now in that shop?

A. No, sir; I couldn't say whether it is there or not; I haven't seen it lately.

X-Q. 13. Was it on that machine that the links for the Steubenville bridge were made?

A. No, sir; I don't think they upset any links for the Steubenville bridge on that machine.

42 X-Q. 14. When were the links made by the upsetting process, that were used in the Steubenville bridge?

A. I am not purchaser for the company, and can't answer that.

X-Q. 16. Were you in the shops, or in the employ of company, at the time arrangements were being made for the building of the Steubenville bridge?

A. I can't say, because I don't know when the arrangements were made.

X-Q. When did you go into the Army?

A. In 1861, April, at first, and was discharged in July or August, 1861; again about July 12th, 1862, and was in then until May, 1863, or thereabouts.

X-Q. 17. When you returned to the shops of the company, in May, 1863, did you find or know of this link-making machine being in use in those shops?

A. Yes, sir; I did.

X-Q. 18. Were links then being made on that machine, as an ordinary matter of business?

A. No, sir; they were making bridge-rods or bars, and not links.

X-Q. Do you mean making them on that machine?

A. Yes, sir.

X-Q. 20. Were those rods that were then being made on that machine flat or round?

A. They were square and round—called square.

X-Q. 21. Were any of them flat and resembling the bar, as exhibited in model E?

A. No, sir.

X-Q. 22. Do you call those round and square rods, which you have described as being then made on that machine, eye-bars?

A. Well, some were bars and some rods; I think there were eyes on one end of them.

X-Q. 23. Were the ends of those rods or bars, which you saw being made, flattened out at the ends in which the eyes were?

A. They were welded round and flattened a little.

43 X-Q. 24. How was this welding done?

A. In the fire, on the anvil.

X-Q. 25. What part of that process, then, to which those rods and bars were subjected, was performed in the machine to which you have referred?

A. The one end that had the screw on. This die was taken out, and a die to form the end on which the screw was to be was substituted. This was after my return from the Army, in May, 1863.

X-Q. 26. How long after this time did you first see used, in that machine, dies for moulding flat eye-bars, similar to that shown in this Exhibit E?

A. I don't know that I ever *seen* them making eye-bars, except when we first experimented.

X-Q. 27. When you first experimented on making flattened eye-bars, how many flattened eye-bars were made for use?

A. I don't know that they were used.

X-Q. 28. Did you ever see a machine in the shops, with dies for making the flattened eye-bar, such as is shown by Exhibit E?

A. Yes, sir; I have seen Mr. Piper's there.

X-Q. 29. At the time you saw it, were the dies in it for making the flattened eye-bar?

A. When I was experimenting, the dies were in it then.

X-Q. 30. After you had done experimenting, and the machine was removed to the shop where the power was applied, did you ever see any eye-bars that were made in that machine?

A. When the machine was moved, I was in the Army.

X-Q. 31. Did you ever see any flat eye-bars that were made in that machine of Mr. Piper, except when experimenting?

A. No, sir.

X-Q. 32. Did you ever, except when experimenting, see that machine with the dies in it making flat eye-bars?

A. Not after it left my shop.

X-Q. 33. If I understand you right, nothing was done in your shop, except experimenting, in the way of making flat bars?

A. That is all.

44 X-Q. 34. (The eye-bar in Exhibit E being shown to witness.) Was this eye-bar, in the form in which it now appears, made upon a machine such as you have described?

A. I do not know anything about that eye-bar in Exhibit E. The eye-bars which were made were something like that, as near as could be made.

X-Q. 35. Did you ever see an eye-bar made upon the machine you have described, with a uniform thickness, without the eye swelling thicker than the bar, in the process of upsetting?

A. You can't get any thicker than the mould will allow.

X-Q. 36. In the experiments you made to form eye-bars in this process, what was the size of the bar which you used?

A. I think it was four inches wide by three-quarters or one inch thick.

X-Q. 37. What was the swell or the increase of breadth of eye thus formed, as compared with the original width of bar?

A. It was made in proportion, about an inch and an eighth on each side, of a swell, or about two and a half inches altogether.

X-Q. 38. In forming this eye on the bar you mentioned, was the bar heated more than once before the eye-end was perfectly formed?

A. Yes, sir, more than once.

X-Q. 39. How often.

A. I could not say; I know more than once. It was a slow process in working, as we had it with a screw and sledging. It wanted a quicker power, and more of it; that is all it wanted to complete the machine.

X-Q. 40. Did you ever see the eye formed by this machine on a bar of the size you have mentioned, at one heat?

A. I have answered that before, as I never saw that machine work after it left my shop on flat bars.

X-Q. 41. Did you ever see the eye formed on that machine without the eye thickening up in the process?

A. As much as the recess in the die would allow, to secure it well; it can't get any larger; it's just the same as running lead in a pair of bullet-moulds.

45 X-Q. 42. How was the top of your mould held down?

A. By heavy strap-hinges, which formed a clamp; made large strap-hinges to go around this machine; the straps were about three inches by one inch. I think there were two. The hinge on the one side and jaw on lower part, and a male end on upper part, to go into the lower jar, with a draw-key hole, and a draw-key drove into that which clamped it all down tight and made it secure.

X-Q. 43. Was Mr. J. H. Linville in Altoona at that time, or about those shops?

A. Yes, sir.

X-Q. 44. Did you ever see him examine this machine, or was he aware that these experiments were being made, or that such a machine was being constructed?

A. I judge he did know something about it, as Mr. Piper was working for the maintenance of way department, with which Mr. Linville was connected.

Re-examined.

Q. 45. I understand that when the machine was used in your shop, the pressure was applied by hand-power; am I correct?

A. Yes, sir.

Q. How many flat eye-bars were upset in the machine in that manner, and what was the quality of them?

A. I can't state how many; there were several upset; of course, we didn't want to waste labor, as it was hard labor. I don't suppose we made more than a half dozen, if that. We just made enough that it would work, and could be done if sufficient power was attached to it. The quality was good—far superior to the ones made by hand; just the same as that pattern; just as perfect.

Q. 47. Do you know whether the eye-bars that were used in the construction of the Steubenville bridge were larger or smaller than those ordinarily used in bridges? If so, state.

A. I could not say whether they were larger or smaller; I never measured them; they were good-sized bars, though.

46 Q. 48. Were they larger or smaller than the die of the machine, as to which you have testified?

A. I can't say that. I think the die that was made for that machine was made large enough for a bridge.

Q. 49. Do you know at whose expense this machine was made, and to whom it belonged when completed? if so, state.

A. Mr. Piper came down to me and told me that he was authorized to have the machine made; authorized by Mr. Lewis, the general superintendent of the road at the time. Under those orders I went to work, and gave all the assistance I could in constructing the machine.

Q. 50. Under whose control was it when you saw it working, in 1863?

A. Under the control of the master-mechanic, the superintendent of the motive power of the road.

Q. 51. What difference, if any, was there in the manner of its use at that time, from the use of it as made in your shop in 1862, other than a change in the form of the die?

A. Nothing more than a knuckle-joint, to apply more power.

Q. 52. Was the die in the machine, as originally constructed in your shop, attached rigidly to the machine, or was it removable?

A. It was removable.

JACOB SZINK.

Sworn and subscribed before me this 24th day of September, 1869.

JOHN RODGERS,
Examiner.

ROBERT NEBINGER, being first duly cautioned and solemnly sworn, deposeth and saith:

Question 1. State your age, place of residence, and occupation.

Answer. My age is forty-four years; residence, Pittsburg; by occupation, a carpenter.

47 Q. 2. Please look at the model now before you, marked Keystone Exhibit E, and state what it represents.

A. This represents a model of the one I made the wood-work for, and fit the iron on, in the car-shop at Altoona.

Q. 3. When did you make the wood-work for the one represented by this?

A. Between the fifteenth day of January and last day of February, 1862.

Q. 4. Was the iron-work completed for it at that time?

A. It was.

Q. 5. Wherein, if at all, other than in size, does the model Exhibit E differ from the machine for which you made the wood-work as above stated?

A. Nowhere, except there were wrought-iron bands on that, which are not on this; the bands were around the outside of the mould to strengthen it.

Q. 6. Under whose directions did you do this work?

A. John L. Piper's direction.

Cross-examination:

X-Q. 7. How are you able to fix the times or dates?

A. I was working at Newton Hamilton's, timbering the tunnel under the railroad, after the first day of January, 1862.

X-Q. 8. Do you know when the Steubenville bridge was constructed?

A. I can't say just now.

X-Q. 9. Do you remember the fact of the preparations for building that bridge?

A. I do not.

Re-examination:

Q. 10. What connection is there between the fact of your working at Newton Hamilton's, after the first day of January, 1862, and the fact of making the wood-work for this machine, by which you are able to fix the date of the latter?

48 A. I was working for John L. Piper, as foreman, which I returned to D. W. Attley, who was master-carpenter, when my book was full which I referred to for the dates. I referred to this when I was last here. The book is not here. I think D. W. Attley has it, unless he has returned it.

(Mr. McMurtrie objects to this mode of fixing dates, the document referred to not being produced.)

I can be qualified that I was at Newton Hamilton's after the eighth day of January, 1862, and that I was there some eight or ten days at the Grandville bridge before I went to Altoona, and then I started the work on this machine.

ROBERT NEBINGER.

Sworn and subscribed before me, this 24th day of September, 1869.

JOHN RODGERS,
Examiner.

OCTOBER 1ST, 1869.

Met pursuant to adjournment. Present: C. B. Collier, esq., for complainant; R. C. McMurtrie, esq., for defendant.

JOHN L. PIPER, a witness on the part of the complainants, Keystone Bridge Company, being produced, and duly cautioned and sworn, deposeth and saith:

Question 1. State your age, your place of residence, and your occupation.

Answer. My age is forty-eight years; residence at Pittsburg, Pennsylvania; my occupation is that of bridge-building.

Q. 2. Are you the same John L. Piper named in the letters-patent Nos. 34183 and 50723, which are sued on in this suit?

A. Yes, sir.

Q. 3. How long have you been engaged in the occupation of bridge-building?

49 A. I think I commenced business in the summer of 1845; have been engaged in that business from that time to this, excepting between March, 1851, until August, 1856.

Q. 4. Will you please state what kind of posts were employed in the construction of iron bridges prior to the date of said letters-patent No. 34183, of January 14th, 1862—whether they were of wrought iron or cast iron?

A. To the best of my knowledge, they were of cast iron.

Q. 5. What are the objections, if any, and difficulties experienced in the use of cast-iron posts for bridges?

A. In the cast-iron posts there is a possibility of their not being sound, or from being honeycombed or blown, or from being hollow posts, one side being thinner, not being of uniform thickness; they are also liable to be broken by a blow.

Q. 6. State the circumstances under which the inventions as described

in the letters-patent of January 14th, 1862, No. 34183, were made, who made such inventions, and when they were made, so far as the same relate to the posts described in said patent.

A. My recollection is, that in 1860, the Pennsylvania Railroad Company decided to build an iron bridge across the Schuylkill River, near the arsenal, in the southern part of Philadelphia, and that they asked for plans for the same, and that it was understood that Mr. Thomson would object to cast-iron posts. At that time I was at Altoona, in connection with Mr. Linville, and commenced making plans and designs for the same. We had a great many different plans suggested and to look into; among others was forming posts of gas-pipes, T-irons, angle-irons, sections of circles, octagonals; and it was finally decided to adopt the octagonal form, made in sections running lengthwise of the post, swelled in the centre by means of spacing-pieces, with cast-iron capital and base cast to the wrought-iron column or shaft of the post.

Q. 7. What do you mean by your statement in your preceding answer, that you had a "*great many different plans suggested*," and will you describe, particularly, those of "*sections of circles*" and "*octagonals*," stating the number of pieces of which they were severally composed, and by what means, if any, such pieces were to be attached to each other?

A. My recollection is, that at first we proposed to use a round column of two semicircular pieces; but, when making inquiry of men engaged in rolling-mill business, they thought it would be very difficult to roll it at all, on account of the difficulty in keeping it in the rolls. We then thought of making it in four pieces, with edges or flanges turned, as that would have remedied the difficulty of keeping it in the rolls; but, on considering the matter further, we concluded that the flanges would spread the carrying or main rods so wide apart where they pass the post, that it would have a tendency to fracture or crack the top chords, or compel us to make them broader than we considered safe to do for the size of posts necessary for a bridge of that length of span. We then concluded to adopt an octagonal of two pieces, semioctagonal, as in that case the corners of the octagon would obviate the difficulty in regard to keeping the sections in the rolls. The latter kind of posts were used in the construction of the Schuylkill bridge.

(Counsel for the Keystone Bridge Company here produces model, marked Keystone Exhibit F.)

Q. 8. Will you please look at the Exhibit F, and state what it represents?

A. With a few exceptions, I should say it represents a section of the Schuylkill bridge at the arsenal.

Q. 9. With what exceptions?

A. One section of the top chord is unlike the Schuylkill bridge; that is, the wrought-iron section marked by the examiner, part 1. You have plates under the eye-bars which are not in the bridge; they are placed under the model for the purpose of keeping the floor-beams in position. There is also a difference between the block on the outside of the top chord in the model and that on the bridge; that don't touch anything that arises in this case. There is no other apparent difference that I can see.

(Counsel for the Keystone Bridge Company introduces model, marked Keystone Exhibit G.)

Q. 10. Will you please look at Exhibit G, and state what the same represents?

A. I should say that it represents, or nearly, the design which was

at one time proposed for the Schuylkill bridge, and which was rejected on account of the flanges; these flanges are cut out where the rods pass.

Q. 11. At what time was it proposed to use posts, such as represented by Exhibit G for the Schuylkill bridge, and will you state whether or not drawings were made of posts of that design?

A. It was during the time that we were getting up plans for that bridge, in 1860, and fore part of 1861, during the summer and fall of 1860. There were no drawings, to my knowledge, made, except with pencil, while the matter was under consideration.

Q. 12. Were drawings of that design made with pencil?

A. There was of sections of it.

Q. 13. Will you please state why posts of the form and design as shown by Exhibit G were not used, and why the form of posts as shown in Exhibit F were employed in the building of the Schuylkill bridge, near the arsenal, in this city?

A. By reason of the flanges projecting too far to allow the rods to pass by them without injuring the upper chord.

Q. 14. What is represented by the cuts in the flanges of Exhibit G, or what is the object of such cuts?

A. I am of opinion they were openings made for the purpose of passing the principal rods.

Q. 15. How are the bases and capitals of the posts employed in the construction of the Schuylkill bridge, as represented in Exhibit F, attached to said posts?

A. The wrought-iron posts were fastened together with rivets and distance-pieces; the patterns of the capital and base were molded in separate flasks, at the proper distances apart, where the wrought-iron shaft was placed to the ends in the moulds to which the bases and capitals were cast to the shaft.

Q. 16. If said posts for the Schuylkill bridge had been made with flanges, what would have been necessary, if anything, in order
52 to have cast around the ends of the posts the capital and base, respectively?

A. It would have been necessary to have the cut flanges off, or made the base and capital much larger than what they are.

Q. 17. What, if anything, was said on this subject at the time you were preparing plans for the construction of the Schuylkill bridge, to wit, during the summer and fall of 1860, and the early part of 1861?

A. I do not recollect anything; there may have been a conversation about it.

Q. 18. Who was the draughtsman that was employed to make the working-drawings for said bridge?

A. Mr. Edward Crueger.

Q. 19. From whom did he receive his specific instructions?

A. From Mr. Linville.

Q. 20. In the letters-patent issued to Linville and Piper, October 31st, 1865, No. 50723, how are the bases and capitals attached to the posts?

A. By rivets passing through flanges cast on the bases and capitals, and the flanges of the sections of the posts.

Q. 21. What is the advantage of the attachment of the bases and capitals, as in the patent of 1865, over the method of attachment as in the patent of 1862?

A. First, it is a great deal less expensive in securing them; that is, the bases and capitals to the column, as in the patent of 1865; in casting them on, as in the patent of 1862; also, in case one of the bases of

the capital would be broken, if made according to the plan of 1862, it would be very expensive breaking off the balance of the metal from the end of wrought-iron shaft, and you would also have to take it to a foundry to get it recast; whereas in the plan of 1865 it would only be necessary to cut the rivets to remove the base or cap; another base or cap could be substituted without taking the column to a foundry. The plan of 1865 also admits of using wrought-iron bases and capitals; whereas they could not be used in the plan of 1862.

53 Q. 22. Will you please state how the sections of the posts employed in the construction of the Schuylkill bridge were prepared, and whether the same is of uniform thickness or otherwise?

A. They were prepared or made by being rolled in proper grooves; they are not of a uniform thickness.

Q. 23. What is the object of having them of variable thickness?

A. For the purpose of having a uniform weight per square inch of section upon the post.

Q. 24. Does the weight increase or decrease from the centre towards the ends of the bridge?

A. It increases according to the distance from the centre to the end.

Q. 25. In the making of the posts for the Schuylkill bridge, how was this unequal thickness produced?

A. I did not see them rolled. I could not answer that from personal knowledge.

Q. 26. What function is performed by the lower chords or eye-bars of iron bridges?

A. The bottom chords of the bridge are subject to a tensile strain equal to the weight of the structure and the passing load; that I would understand to be the office of the bottom chord.

Q. 27. Upon what part of the chord is the strain greatest?

A. The centre of the span.

Q. 28. Will you please state how the lower chords, as employed in the construction of the Schuylkill bridge, were made?

A. They are made—each truss has four strands of lower chord or eye-bars, varying in thickness and width according to the position they occupy in the truss; the ends where the connecting-pin passes through are widened out sufficiently to leave a section at the centre of the pin-hole equal to the section of the bar between the enlarged ends.

Q. 29. Will you please state how such enlarged ends were made?

A. They were made with a forge hammer.

Q. 30. Will you please look at the model, Exhibit E, and state what the same represents?

54 A. A machine that I got made in the spring, or during the winter of 1862, for the purpose of making eye-bars for bridges, with some few exceptions that are not like the original; these fastenings are not like the original; they were heavy bars of wrought-iron that went around the box, with joints on the back side, and in front they pass by each other, with a suitable opening for the purpose of driving a key to hold it together.

Q. 31. Where was said machine made, and who did the work upon it?

A. It was made in the Pennsylvania Railroad Company's shop, at Altoona; Mr. Boyden made the patterns, and Mr. Maxwell had the castings made; Mr. Szink made the wrought-iron work, and Mr. Nebinger made the frame and put the machine together.

Q. 32. Give the dimensions of the machine, and state where it now is.

A. I could not give exact dimensions. My recollection is that the box-part, where the end is formed, is about twenty inches wide; I think

thirty inches or three feet long, and about eight inches in depth. The machine at present is in the Altoona shops, or was, a month since, with the exception of the large box, where the dies are held.

Q. 33. What use, if any, was made of this machine by yourself, after its construction?

A. After it was constructed we took it into the blacksmith-shop and used it for upsetting flat bars into the shape we were using for lower chords of bridges.

Q. 34. When was this?

A. In the spring of 1862.

Q. 35. How did it answer the purpose for which it was designed?

A. As first constructed, with the screw, the screw was found to be too slow *for* to work successfully; otherwise the machine worked well.

Q. 36. What means, if any, were employed for applying the power, other than the screw?

55 A. Afterwards we took out the screw, and instead of it used what is usually called a toggle-joint, moved by an eccentric, and driven by steam-power, with a wedge to be applied between the end of the toggle joint and the end of the follower or movable part of the die, for the purpose of getting sufficient motion in the movable part of the die to upset any required length.

OCTOBER 26TH, 1869.

Present: Mr. Collier, for plaintiffs; Mr. McMurtrie, for defendants.

Examination of JOHN L. PIPER resumed.

Q. 37. Have you seen in use machines for upsetting chords for bridges similar to the one constructed at Altoona; if so where?

A. I have seen such at Pittsburg. We have one at the Keystone Bridge Works.

Q. 38. How does it answer?

A. Answers satisfactory.

Q. 39. State whether or not, prior to 1864, you had a conversation with George H. Sellers relative to the making of chords for bridges by the upsetting process; if so, state when said conversation was had, and what was said.

A. I had such conversation with Mr. Sellers at Phœnixville, in the fore part of February, 1863; it may be the 9th; I think it was; I may be mistaken. Piper & Shiffler were then in company as partners, and we had taken a contract to build a bridge across Mayland Creek, West Philadelphia, in which we had agreed to use eye-bars for lower chords. I had understood that the Phœnix Iron Company had contracted with the Pennsylvania Railroad Company to made the eye-bars for the channel span of the Steubenville bridge, and I went to Phœnixville to see if we could contract with them to make them for Mayland's.

56 In conversation with Mr. Sellers, at that time, I described to him the manner in which we had made eye-bars at Altoona. I told him how we had undertaken to make them by turning over the ends of the bars and welding the two thicknesses together, for the purpose of getting a head sufficiently broad to admit of boring out the hole for the pin, without reducing the section at centre of pin to a less size than the section of the bar between the heads; also, by welding pieces on the side of the bar to form the heads; which modes did not prove satisfactory. I then told him that I got a set of dies made for the purpose of seeing whether we could not make these bars by upsetting. I told him that we tried these dies by driving the follower in with sledges; and

after making some in this way and submitting them to the engineers and superintendent of the road, they were so well satisfied with them they directed me to go on and get up a machine for the purpose of doing it by power. I told him that I had then got up a machine with a screw as the power, similar to Exhibit E, and that we had made some eye-bars with the machine that were perfectly satisfactory, but that we had discovered, in making them, that our power was not sufficient, in the way we have it arranged, for to make them economically, and I advised him to be careful, in getting up his machine, to have this power ample.

Q. 40. To whom did the Altoona machine belong, and at whose expense was it made?

A. To the Pennsylvania Railroad, and it was made at their expense.

Q. 41. At the time of this conversation with Mr. Sellers (February, 1863) did Piper & Shiffler, or J. H. Linville, have a manufacturing establishment?

A. Piper & Shiffler had none, and J. H. Linville had none, that I know of.

Q. 42. When was the Keystone Bridge Company organized?

A. May 1st, 1865.

Q. 43. Will you state whether or not, prior to 1862, or during
57 that year, you had any conversation with either of the officers of the Phœnix Iron Works relative to the construction of wrought-iron posts for bridges? If so, state with whom such conversation was had, when and where, and what was said.

A. I had a conversation with a gentleman who introduced himself to me as Mr. Walters, engineer of the Phœnix Iron Works—the civil engineer I understood him to be—to the best of my recollection, in December, 1861, or January, 1862. This was on the Schuylkill bridge, near the arsenal, Philadelphia. When I came on to the work in the morning, I observed a gentleman upon the west span of the bridge, who appeared to be examining it; when I came to where he was, he introduced himself to me as Mr. Walters, engineer of the Phœnix Iron Company, and stating that he had come down for the purpose of examining the bridge. I took him around, and we examined it together; after which Mr. Walters remarked that the bridge appeared to be more perfectly or accurately arranged to the strains than any bridge he had seen, with the exception of the posts, which appeared to be all of the same size. I then explained to him that, although the posts were of the same size outside, they were graduated to their respective strains by means of the pieces being rolled thicker or thinner, as their respective positions would require; and to satisfy him we went along and put our fingers into the openings between the parts, where we could ascertain the different thicknesses by the feeling; after which Mr. Walters remarked that he considered it the most perfectly proportioned bridge that he had ever seen.

Q. 44. Calling your attention again to Exhibit F, and to your answer to Question 9, will you please state whether or not the part marked by the examiner 1 represents the top chords, as described in the letters-patent to Piper & Linville, No. 50723?

A. It does.

Q. 45. What are the advantages, if any, of top chords, as shown by said part 1?

A. The advantage of that formation is, that the channel-bars and eye-beams have their greatest depth up and down, perpendicular;
58 the top and bottom plates, their greatest depth is horizontal.

When combined together by rivets, as in Exhibit 1, top and bottom plates support the eye-beams and channel-bars from deflecting horizontally, and the eye-beams and channel-bars will prevent the plates from deflecting perpendicular when placed under compression. They are made in sections lengthwise, of one panel in length, whatever the panel of the bridge may be, which is for the purpose of greater convenience in transportation and placing them in their respective positions in the bridge.

Q. 46. Calling your attention to Exhibit D, will you please state when and where posts of that form—having the capitals and bases riveted thereto—were first used by yourself and Mr. Linville, or by the Keystone Bridge Company?

A. They were first used in the centre span of bridge near Dauphin, on the Northern Central Railway. The time that we put that up I couldn't be positive of. It was either in the fall of 1865 or 1866; I think it was in 1866.

Q. 47. Will you state the time of the invention by Linville & Piper of the upper chords, and of the wrought-iron capitals and bases, respectively, such as shown and described in their letters-patent of 1865?

A. To the best of my recollection, Mr. Linville and myself had our first general conversation in the fall of 1864, as to that plan. The final drawings, which were submitted to the Patent-Office, I think, were made in the spring of 1865.

Adjourned to meet on Tuesday, November 2d, at 10½ o'clock a. m.

NOVEMBER 2D, 1869.

Present: Mr. Collier, for plaintiffs; Mr. McMurtrie, for defendants.

Cross-examination of JOHN L. PIPER.

Cross-question 48. Were you connected with Mr. Linville in the construction of the Steubenville bridge?

59 Answer. Mr. Linville was the engineer, and Piper and Shiffler had the contract for building the superstructure.

X-Q. 49. Had you any consultations together on the subject of the work?

A. Yes, sir.

X-Q. 50. Were there any consultations on the subject of the columns to be used for that work?

A. Yes, sir.

X-Q. 51. When was that bridge begun, and when was it finished?

A. The drawings were got up in 1862, I think. The superstructure of the bridge was commenced in 1863, and finished in 1865.

X-Q. 52. You have referred to a consultation in answer to the seventh question in chief—when was that consultation?

A. I could not give you the day of it; but it was when we were getting up the plans for the arsenal bridge, in 1860 or 1861.

X-Q. 53. Was it before the plan was made, the drawing of which was submitted to Mr. Thomson, as stated in this examination?

A. My recollection is that it was.

X-Q. 54. Did I not understand you to say when that plan was submitted to Mr. Thomson, in the first instance, it was proposed to make the columns of cast iron?

A. My recollection is that I said it was generally understood that Mr. Thomson would object.

X-Q. 55. Do I understand, then, that the designing of wrought-iron

posts, of some kind or other, preceded the making of the plan that was submitted to Mr. Thomson?

A. My recollection is that we had several conversations, the subject of which was wrought-iron columns for bridges, during the making of the plans that were submitted to Mr. Thomson.

X-Q. 56. I call your attention to what was said by Mr. Crueger, on page 3 of the testimony, in reference to Plan A. Did the consultations in reference to wrought-iron posts precede or follow the submission of that plan?

(Drawing A exhibited to witness.)

60 A. My recollection is that we had conversations relative to wrought-iron posts previous, as well as subsequent, to the making of that plan.

X-Q. 57. At what date do you remember a proposition for a mode of making wrought-iron posts being made, which were to be composed of more than two pieces, with flanges?

A. I couldn't tell, sir, at what date. I couldn't tell the date of any of these conversations. It was during the time we were getting up plans for the building of this bridge, in 1860 or 1861.

X-Q. 58. What is the earliest date that you can fix as having seen or heard of the plan for making posts composed of more than two pieces, rolled in the shape as in Exhibit D, or in segments of a circle, with flanges?

A. It was previous to building the bridge near the arsenal. Mr. Linville proposed using posts with flanges, and I did not like the plan, and finally got him to adopt a plan without flanges. I thought it would spread the rods too far apart for the upper chords, and I didn't admire it as much as the other form. Mr. Linville proposed cutting the flanges off where the rods passed, but it was thought this would weaken the posts too much at the point where it ought to be strongest.

X-Q. 59. Of how many pieces was this proposed post to be made?

A. I don't recollect whether it was two or four, because there was an objection to the flanges; and I don't recollect of seeing any drawings, except pencil-sketches on paper. We were talking of two and four pieces to the post.

X-Q. 60. Had you any knowledge of Mr. Linville's application for the patent of January, 1862?

A. Yes.

X-Q. 61. Did you see the papers before they were sent on to Washington—specifications and drawings?

A. I am not certain that I saw the papers that were sent there. I saw copies of them; I should say the originals from which they were made.

X-Q. 62. Why was that specification confined to columns to be composed of two pieces?

61 A. It does not call for columns of two pieces; it calls for columns composed of two pieces of a certain size, or their equivalents.

X-Q. 63. Do I understand you to mean or imply that under the word equivalents was embraced the using of more than two pieces in making the column?

A. I have always understood that we had a right to make the column of as many pieces as we chose to form an octagon or circle, and in our specification we mentioned that they may be made of T or L shaped pieces Our intention was, that if we used T-iron, to use two of them spread apart and riveted through the flanges. If we used L, or angle-iron as it is usually called, to use four pieces riveted through the flanges.

X-Q. 64. You considered, then, that the word equivalents covered *to* claim for the use of any number of pieces?

A. It was considered that our claim of two semicircular or semioctagonal pieces, or their equivalents, gave us the right to use any number of pieces we might choose to use in the construction of an octagonal or circular post.

X-Q. 65. Why was all reference to flanges, or pieces with flanges, omitted in that specification and patent?

A. I know of only one reason, and that is, we were not as familiar with patents at that time as some other persons, and we depended upon our attorney, who got up the papers.

X-Q. 66. You have said that, when planning the arsenal bridge, you objected to the proposed pieces with flanges for columns there, as suggested by Mr. Linville. Had you at any time, and when, after so objecting, and before the preparation of the specification of the patent of January, 1862, perceived the error of your so objecting, and the advantage of having pieces with flanges?

A. I have not perceived any error yet for my objection in that particular bridge.

X-Q. 67. Mr. Crueger, on page 5 of his testimony, question 10, states that Mr. Linville also objected to flanges. When did you hear Mr. Linville say, after that, that his objection to flanges was removed?

62 A. I don't know when Mr. Linville made the objection to Mr. Crueger, but I am very certain that Mr. Linville did make the suggestion to use flanges.

X-Q. 68. These points, viz., the use of more than two pieces, the use of pieces rolled with flanges, and the mode of fastening those pieces by rivets through the flanges, are claimed, in the patent of 1865, as improvements on the patent of 1862. When were they discovered or ascertained to be improvements?

(Objected to by counsel for the Keystone Bridge Company, for the reason that the question does not state correctly the claims of the patent of 1865, nor the entire subject-matter of either of the three claims of said patent.)

A. I think it was in the fall of 1864. Mr. Linville and myself undertook to get up a plan for an entire wrought-iron bridge, and the improvement spoken of was, as I understand it, the using of wrought or cast iron caps and bases secured to the shaft of the column by being riveted on instead of cast around the shaft, as in patent of 1862; and, as our top chord could be made broader than our cast-iron, as in the patent of 1862, the flanges of the post would not be objectionable, as in the case of the arsenal bridge. We therefore adopted the flange as a matter of convenience—not that it would make the post any stronger.

X-Q. 69. I will read you the specification in the patent of 1865, from the words *our invention* down to *second*. I ask you to say whether the use of more than two pieces—the use of pieces with flanges and the mode of fastening by rivets through the flanges—are intended to be claimed as improvements or not; and if they are, when were they ascertained to be improvements?

A. I understand that patent to be drawn up from the model which was before the attorney who drew it up. We consider the bases and capitals secured in the manner as therein described an improvement. We consider a wrought-iron base an improvement on the cast-iron one, and I considered, and do now, that the using of flanges in the manner the post was constructed a convenience, or more convenient than riveting through the body of the post for the purpose of securing the capital and

63 base. I do not consider the post any stronger than without the flanges—the same amount of material being in the sections in the two cases—that is, with and without flanges.

X-Q. 70. My question has not been answered, whether any or which of these particulars were considered improvements; secondly, when they were ascertained to be improvements.

A. (Objected to, as assuming that the preceding question has not been answered, whereas it has been fully answered by the witness.) I answered the question as I understood it to be answered.

X-Q. 71. When was it ascertained to be an improvement on the patent of 1862, to form a column of more than two pieces of rolled iron?

A. I don't understand that we have ascertained more now than in 1862, when we proposed to make the column of two and four pieces.

X-Q. 72. When in 1862 you proposed to make a column of four pieces, what was the sectional form of those proposed pieces?

A. One form was to make them of four-angle or L-iron; one was to make them of four gas-pipes, spread apart, with spacing-pieces between them, and confined by bands, and we also proposed to make them of octagonal form, with flanges, which was objected to, as before stated.

X-Q. 73. Why was not that form alluded to or described in the specification of the patent of 1862?

A. I can't answer that, as Mr. Linville drew up the form, and I judge the drawing was made from a copy of the drawing of the Schuylkill bridge.

X-Q. 74. When was it ascertained that rolling the pieces of the column, with flanges, was an improvement?

A. I do not know when it was—as I understood it to be a convenience for fastening the bases and caps when they are fastened with rivets, as in the patent of 1865, instead of being cast around the post.

X-Q. 75. Do you think, then, that the use of flanges is no improvement in any other particular?

64 A. I don't consider it an improvement in any other particular, except I consider it more convenient in fastening the pieces together longitudinally.

X-Q. 76. Where there are no flanges, the mode of fastening was, I believe, by rivets through the body of the column?

A. Yes, and by means of casting caps and bases to the ends.

X-Q. 77. When flanges were introduced, there were no rivets put through the body of the column, but through the flanges, I believe?

A. That is the case.

X-Q. 78. Is this change an improvement?

A. I don't know that it is.

X-Q. 79. How many bridges have been built since the arsenal bridge was built, in which the columns were composed of two pieces without flanges, similar to those used in the arsenal bridge?

A. To my knowledge, not any.

X-Q. 80. What sort of columns are used in the Steubenville bridge?

A. Cast-iron.

X-Q. 81. What bridges have you constructed with columns composed of more than two pieces with flanges, since the arsenal bridge—the cross-section such as is in Exhibit F, or with columns similar to Exhibit D?

A. Not any since the arsenal bridge of that pattern of F. We have constructed quite a number with columns such as Exhibit D.

X-Q. 82. When was this model made—Exhibit D?

A. I don't know.

X-Q. 83. Referring to your answer to question 11, (read to witness,) did those drawings to which you refer in your answer to question 11 exhibit the mode of fastening the pieces together?

A. I don't think that they did.

X-Q. 84. I understand you to say that there was no model or specimen or finished drawing made at that time?

65 A. There was none made at these interviews; there was a model made of a post composed of four gas-pipes, with the base and capital cast on the end, and secured by bands to spacing-pieces. The only other model I know of was the one sent to the Patent-Office.

X-Q. 85. Was any rolling-mill consulted at that time, sir, as to the feasibility or advisability of rolling-pieces for columns composed of segments of a circle or polygon, less than the half-circle or half-polygon, and with flanges, or of such segments without flanges?

A. I don't know of any rolling-mill consulted for the segment of a circle less than a half-circle; they were consulted as to the half-circle; as to the polygon, I do not know.

X-Q. 86. What was the mill that was consulted?

A. I personally consulted Mr. Algernon S. Roberts.

X-Q. 87. Who was it that made these sketches or drawings of designs for forms of posts referred to in answer to the eleventh question, or at any time prior to making of plan for arsenal bridge?

A. The designs spoken of as being sketched or drawn in our interviews were sometimes made by Mr. Linville and sometimes by myself.

X-Q. 88. Who was it made the drawing of the plan that had the flanges to it?

A. I think Mr. Linville made it, as he was the one suggested it.

X-Q. 89. Which of you objected to the flanges?

A. I did.

X-Q. 90. Did Mr. Linville make any such objection?

A. I don't know that he did; I succeeded in satisfying him that some other form would be better for that bridge.

X-Q. 91. Were you present at the interview referred to by Mr. Edward D. Crueger, when sketches of proposed posts for that bridge were being made?

A. I do not recollect of any particular interview between Mr. Crueger, Mr. Linville, and myself; Mr. Crueger was the draughtsman, and I was in and out of the office frequently when the plans were being prepared.

66 X-Q. 92. Were you present at any interview at which Mr. Linville and Mr. Crueger were both present, at which sketches were made for the posts of that bridge—on which sketches pieces were designed with flanges?

A. I don't know that I was present with Mr. Crueger and Mr. Linville when sketches of that character were made, and do not know but what I was, as Mr. Crueger was frequently in the office in the evenings.

X-Q. 93. Did you ever see a letter from S. J. Reeves to Mr. Linville, dated January 5th, 1863, an extract of which is found on page 7 of the bill, Reeves vs. Linville, and now shown to witness?

A. I have no recollection of seeing it.

X-Q. 94. Did you ever hear of it?

A. Not to my knowledge. I have heard Mr. Linville say, within the past year, that he had had some correspondence about links. I have no recollection of having heard him say that he had any correspondence about posts.

X-Q. 95. Please to read copy of a letter from George H. Sellers to

Mr. Linville, dated June 26th, 1863, found on page 7 of said bill. Did you ever see or hear of that letter?

A. I don't think I ever did.

X-Q. 96. Did you ever see the specimens of posts referred to in that letter?

A. I saw a specimen of a post that I was told was sent by Mr. Reeves, but do not know whether it was the one referred to in that letter.

X-Q. 97. Where did you see it?

A. In the shops of the Pennsylvania Railroad Company at Altoona. I was told it was sent there to be tested with a hydraulic press.

X-Q. 98. Of how many pieces was that post composed?

A. To the best of my recollection, four pieces—rivets, cap, and base excepted.

X-Q. 99. What was the form of the cross-section of each piece composing the shaft?

67 A. It was a quarter-circle, with the exception of a flange at each edge.

X-Q. 100. When was this—wasn't in in July, 1863, or thereabouts?

A. I think it was much later than that when I at first saw it.

X-Q. 101. When was an objection suggested, that this form had already been invented by Mr. Linville, or by Messrs. Linville & Piper?

A. I told Mr. Linville that I thought Mr. Reeves had got our post, and introduced flanges in the way we had used it in the Schuylkill bridge.

X-Q. 102. Which Schuylkill bridge do you refer to?

A. The one at the arsenal.

X-Q. 103. In what way did that post of Mr. Reeves, that you saw there, differ from Exhibit D, so far as the shaft is concerned?

A. The column Mr. Reeves sent to Altoona was composed of four pieces of a quarter-circle, with a flange on each edge of the pieces, instead of a quarter-octagon; it had no spacing-pieces between the flanges or edges. The flanges were riveted close together. At each end the flanges were cut off about an inch or inch and a quarter up from the end, with a cast-iron shoe, having a recess in it for the end of the shaft to set in, instead of having a base and cap like Exhibit D.

X-Q. 104. Had not this column of Mr. Reeves a base and a cap upon it?

A. It had a cast-iron base or shoe to set on on either end; they were both alike.

X-Q. 105. How *was* the base and cap fastened?

A. They were not fastened at all.

X-Q. 106. What was your connection with the Keystone Works?

A. I was the first two years the president, and since then the general manager.

X-Q. 107. What is Mr. Linville's connection with that establishment?

68 A. He is our president.

X-Q. 108. Did they make the columns for the arsenal bridge?

A. No, sir.

X-Q. 109. Where were they made?

A. In the Pennsylvania Railroad Company's shop at Altoona.

X-Q. 110. What shop made the column for the connecting railway bridge over the Schuylkill?

A. Pennsylvania Railroad shop at Altoona.

X-Q. 111. Have either the Pennsylvania Railroad shop or the Key-

stone Works, since the building of the South street bridge, made any pieces for columns composed of two pieces only, with flanges?

A. I think not.

X-Q. 112. When was it that you first saw columns or posts made of rolled iron composed of more than two pieces with flanges?

A. I can't give the exact date. I think that Mr. Reeves's piece was the first one of that kind.

X-Q. 113. In what structure did you first know a post made in that way to be used?

A. I can't answer where. The first bridge I know of was the Dauphin bridge of the Northern Central Railroad, which I have already referred to in my examination-in-chief; that was in 1866.

X-Q. 114. Is the post of Mr. Reeves an improvement on the post described in Mr. Linville's patent of January, 1862?

A. I do not consider it so.

X-Q. 115. Then please state in what respects the post, as described in Linville & Piper's patent of 1865, is an improvement on the post described in the patent of January, 1862.

A. The improvement consists in the patent of 1865 of using either a cast or wrought cap and base, and being able to remove either of them, if required, with but very little expense, and without taking them back to a foundry.

X-Q. 116. Would not a column formed of two pieces, as described in Linville's patent of 1862, when under pressure, bend first on one of the sides which was nearest to the centre, assuming that the fastenings did not break?

A. I have been informed, as the result of trials that were
69 made with them, that they did not.

X-Q. 117. On which side did it bend first?

A. I was informed that it deflected in the direction of the greatest diameter of the post. I did not see the test, but such was my information.

X-Q. 118. Is it not a law of mechanics, that a column of an elliptical shape, whose greatest diameter is eight and the smallest four—the sections being of equal thickness—will first deflect under pressure in the direction of the smallest diameter?

A. I can't answer as to the law; we generally expect a thing to go the narrow way.

X-Q. 119. Can you explain, then, why the experiment made upon Mr. Linville's column showed that to be an exception to the general rule?

A. The sections in the first plan are not of equal thicknesses all over; and were not the ends so perfectly secured that they could not move under pressure, I presume that they would deflect in the direction of the greatest diameter, because if they could move at the ends they would be reduced to two pieces of one half the width of the narrow diameter.

X-Q. 120. Are you at all acquainted with the art of rolling iron?

A. I have been about rolling-mills considerable, but I do not profess to be an expert.

X-Q. 121. Have you ever seen the wrought-iron flange-pieces used in posts similar to Exhibit G when they were being rolled in the mill?

A. No, sir.

X-Q. 122. What is the greatest segment of a circle which you have seen rolled—a quarter, third, or half?

A. I don't know that I have ever seen the segment of a circle rolled.

X-Q. 123. Have you ever seen the segment of a polygon rolled?

A. Yes.

70 X-Q. 124. What is the greatest measure of the central line of such a piece that you have seen rolled?

A. The greatest I have seen rolled of an octagon was a quarter of an octagon, which would be enclosed in a circle eight inches in diameter—the iron being three-eighths inch thick.

X-Q. 125. Is there any difficulty in rolling such pieces of iron with suitable rolls in any ordinary bar-mill?

A. I think not.

X-Q. 126. Would there be any difficulty in varying the thickness of the pieces in the same set of rolls?

A. I think not.

X-Q. 127. Suppose, instead of four pieces as just described, compose a column of eight inches diameter, you wish to roll such a column of two pieces only—each semicircular—the pieces having flanges of the same size; would there be any difficulty of rolling such pieces in an ordinary bar-mill with suitable rolls?

A. I think not.

X-Q. 128. What would be the length, in inches, of the versed sine of such a piece?

A. About three inches and thirteen-sixteenths of an inch.

X-Q. 129. Would it not be necessary, in rolling pieces of this kind, to cut the grooves of the rolls much deeper than would be necessary to roll similar pieces for similar columns in four pieces?

A. I think it would.

X-Q. 130. Is not the thickness of the pieces intended to be rolled increased by raising the roll?

A. By increasing the distance between the rolls.

X-Q. 131. When rolling two segment pieces and varying the thickness by separating the rolls, would the thickness be uniformly increased, or would it not be more increased at the bottom of the curves than at the sides?

A. I have never seen any rolled. My impression is that it would not be uniformly increased. It would be more increased at the bottom than at the sides.

X-Q. 132. Would not the flanges also be increased in thickness just as the bottom of the curve?

71 A. I think they would be increased in the same proportion.

X-Q. 133. What would be the effect on a piece thus rolled of varying thickness in its different parts by the process of cooling?

A. I think the thin parts would cool the quickest, if it had an equal chance with the rest, or as equally exposed with the thicker part.

X-Q. 134. What result would follow from that—as to the strength of the iron from the shrinkage?

A. I can't answer that question. As to cast iron, if one part shrinks before another it causes a strain on it. As to wrought iron, I do not know what the effect is, or whether the same effect will follow.

X-Q. 135. In varying the thickness of a two-segment piece, can as great a variation be accomplished in one set of rolls as could be done on the same rolls in which a four-segment piece is made?

A. I think it would depend on the construction of the rolls.

X-Q. 136. Will not the increase of the area of the pieces be greater when a four-segment piece is rolled, than when a two-segment pieces is rolled, by the same amount of the separation of the rolls?

A. I do not think it would.

X-Q. 137. If, in the four-segment piece, there is greater uniformity by

increasing the difference between the rolls, than the two-segment pieces, does it not necessarily follow that a greater area is produced by a separation of the rolls in the four-segment than in the two-segment pieces?

A. I think not, because the two-segment pieces are twice the size of the other.

X-Q. 138. How would it be if the length of the central line of both were the same?

A. It would be, under those circumstances, increased in the quarter-circle.

X-Q. 139. It is not, then, sir, of an importance and an advantage, in view of these circumstances, to make the column of more than two pieces?

72 A. I don't know that it would be material, as the same rule does not apply on an octagon post as a circular post.

X-Q. 140. Are not the pieces of a column more readily rolled and more readily increased or diminished in thickness just in the proportion as they approach to a flat surface?

A. I do not think there would be much difference, as the same process would effect the same result.

X-Q. 141. Suppose you were required to make two-segment columns, with flanges, sixteen to twenty inches in diameter, do you know of any rolling-mill that, with their present machinery, could roll such columns in two segments?

A. I think I know of mills which, by making rolls for that purpose, could make such posts.

X-Q. 142. What size rolls and what power of engine would be required to do such work?

A. I presume they could be done by different size rolls; I presume housings that would take on three twenty-two-inch rolls would do for that work.

X-Q. 143. Where is the mill that has the power and length of train sufficient to do such work?

A. I should think probably the Buffalo Iron-Works; also, the Phœnix Iron-Works; also, the mill of Mr. Moorehead at Pittsburg.

X-Q. 144. You alluded above to a mill that could do such work; what mill was it that you referred to there?

A. The mills that I have mentioned are the ones that I refer to.

X-Q. 145. Can you form any idea of the relative cost of rolling such columns in two segments, as compared with six, eight, or more segments?

A. I couldn't, sir.

X-Q. 146. What would be the safe diameter of a set of rolls that would make pieces for a two-segment flange column twenty inches in diameter of body?

A. I am not familiar enough with the proportions of rolls to answer the question.

X-Q. 147. Are not long columns of large diameter, and of the

73 same sectional area as columns of smaller diameter, and of same length, stronger and stiffer than the latter?

A. I think they would be.

X-Q. 148. Suppose you were required by a engineer to build a bridge 320 feet long between the supports, to carry a load of one ton to the foot, independent of the weight of the structure, the height of which is to be one-twelfth the span, and top chord of which is required to be made of wrought iron, in the same manner as columns are made—do

you know of any works in the country where chords of such area could be rolled in two segments?

A. I do not.

X-Q. 149. Look at Exhibit H, and say if you know any mill competent to roll segments of columns of the dimensions shown in that drawing, and of the varying thickness as there shown.

A. I think I know of mills which, if they had the rolls, could roll them. I think William Lyon's mill, of Pittsburg, has power enough to do it, or Mr. Moorehead's mill.

X-Q. 150. How many sets of rolls would be required to do such work as that?

A. I think it would depend on the length of the piece required to roll, or the amount they would require to be reduced at each pass.

X-Q. 151. How many of those varying thicknesses could be rolled under one set of rollers; or, to put it in another way, how many set of rollers must there be to roll all those varying thicknesses of iron?

A. I think they could finish them in one set of grooves, or they could have a set of rolls for each thickness, as the party rolling might determine.

X-Q. 152. Look at Exhibit I, and say how many sets of rolls would be required to roll columns of the size above mentioned in segments of this shape.

A. Where the Keystone Bridge Company get their iron rolled, the variation in thickness can be made in one set of rolls depends on
74 the depth of the collars. I would therefore suppose that if the collars were made of sufficient depth they could be made in one set of rolls sufficiently accurate for practical purposes, although each different segment would vary slightly in uniformity of thickness. I think this could be done in one set of rolls.

X-Q. 153. Can you give any idea of the relative expense of rolling such a column in pieces, as described in Exhibits H and I?

A. I could not.

X-Q. 154. Do you know what is the relative power required to roll a bar or rolls of sixteen inches in diameter, and on rollers of twenty-four inches in diameter?

A. I do not.

X-Q. 155. When were eye-bars first made without welding by the process of upsetting?

A. To the best of my knowledge, in 1861.

X-Q. 156. Where were those made?

A. At Altoona.

X-Q. 157. Where were the eye-bars so made used?

A. They were not used at all for bridge purposes.

X-Q. 158. What was their size?

A. My impression is they were about three inches wide by five eighths of an inch, or three quarters, thick. They were, I think, one-half the size of the links we had been using in bridges.

X-Q. 159. Were these made on Mr. Linville's machine.

A. At first they were made simply with dies or forms clamped together, the movable part of the die being driven in with sledges; we afterwards made a machine, which Exhibit E represents, in which we made more of them.

X-Q. 160. Were any of the eye-bars made on that machine ever used in practice; and if so, when, for the first time?

A. I do not know whether there was any made of it; there was not

for the first year, at which time I left the service of the Pennsylvania Railroad Company.

X-Q. 161. What is the largest size bar that you ever knew formed into an eye-bar on that machine?

A. The bar of the size I have mentioned.

X-Q. 162. Where is the box in which those bars were formed now?

75 A. I do not know.

X-Q. 163. How many heatings did it require to form that eye-bar?

A. Sometimes we could upset them by heating twice; at others three or four times, in consequence of the power we used being slow.

X-Q. 164. Was anything done to the eye-bars, in the way of finishing, after they left the machine in which they were upset; if so, what?

A. There was. The machine did not hold the die so perfectly rigid but that the bars would increase their thickness. After being taken out of the dies they were reduced to the required thickness by being hammered, and afterwards trimmed off to the required shape.

X-Q. 165. Look at the eye-bar in Exhibit E, and say whether that has been finished in the way you have mentioned since the upsetting process.

A. I think it has, from the appearance of it.

X-Q. 166. Where were the eye-bars made that were used as links on the Steubenville bridge?

A. They were upset at the Phœnix Iron-Works.

X-Q. 167. Do you know why that company was employed to make those bars, and why they were not made on Linville's machine?

A. Mr. Linville, or the Pennsylvania Railroad Company, had no machine of sufficient capacity to manufacture links of the size required for the Steubenville bridge, and I was informed that Mr. Reeves agreed to get up one of sufficient capacity providing the Pennsylvania Railroad Company would give him the order for the links.

X-Q. 168. Look at the correspondence and documents, copies of which are set forth in the answer filed in the case of October sessions, 1867, No. 45, from page 12 to page 19, inclusive, and say whether any, and which part, of that correspondence was known to you, and when?

A. I have no recollection of seeing any of this correspondence, except the letter dated February 17th, 1863.

76 X-Q. 169. When did you first hear of such a correspondence?

A. I heard that Mr. Reeves had contracted to make the links for the Steubenville bridge in the fore part of 1863, I think; I might have heard of a correspondence relative to it, but was not acquainted with the particulars of it.

X-Q. 170. Mr. Linville claims in his patent of 1862, first, the construction of the lower chords, &c. What proportions between the width and thickness of the bar must exist to bring a bar within the definition of a wide and thin bar, or is there any definite proportion necessary to warrant the application of those terms to a bar?

A. I would understand it to mean that the bars were of such shapes as come within the manufacturers' term called "flat bars."

X-Q. 171. Would a bar nine inches wide and one inch thick come within the description of a wide and thin bar?

A. Any bar that was wider than it was thick would come within the description.

X-Q. 172. (Mr. Linville's patent of 1862, and Linville & Piper's of 1865 being shown to witness.) Please state what is the difference between the claims in these patents, so far as respects eye-bars, other than this

—in the earlier patent the use of eye-bars formed with wide and thin bars is claimed without regard to the mode in which they are made; in the latter, the same use of these bars is claimed when made by the upsetting process.

(Objected to as calling for testimony as to that which is matter of law to the court.)

A. My understanding of the patent of 1862 was, that the claim covered the use of eye-bars for lower chords of bridges, without regard to how they were manufactured, for the reasons therein stated. The patent of 1865 was intended to cover the manufacture and use of eye-bars made by being upset in dies of the required shape.

X-Q. 173. Will you point out, in the patent of 1865, where there is any allusion to the mode in which eye-bars can be made by the upsetting process?

77 A. I find it here. The lower chords, D, consist of wide, thin, rolled iron bars, with enlarged ends, &c., as set forth on page 7 of printed copy.

X-Q. 173½. Was not die-forging practiced before 1860?

A. I am not aware of it, except for rivet-heads or something of that kind, which I would not term die-forging, in the sense in which it is used in the patent of 1865.

X-Q. 174. How are the heads of machine-made rivets formed?

A. In a recess in the end of a follower—it being pressed against a plain surface.

X-Q. 175. How long has that been practiced?

A. Before 1860, I think.

X-Q. 176. How were the heads of cut nails made before 1860?

A. I am not familiar enough with the process of manufacturing nails to answer correctly.

X-Q. 177. Did you ever see a screw-bolt swelled under the bolt-head into an elliptical shape to keep it from turning in the hole in which it was intended to fit?

A. I have seen screw-bolts swelled under the head to prevent them from turning.

X-Q. 178. How is that swelling formed—by a pressure or by blows?

A. It might be formed, I think, either by pressure or blows.

X-Q. 179. Are they not in fact formed in dies by pressure?

A. I have never seen them formed in that way.

X-Q. 180. If so formed, would you call that upsetting?

A. Yes, sir.

X-Q. 181. What is meant by the phrase "process of upsetting?"

A. What I would understand would be to increase the area of the iron by decreasing its length—this being done either by pressure or hammering.

X-Q. 182. Referring to Exhibit H, could the Keystone Works, with their present machinery, roll a column in two sections of that size?

A. No, sir.

X-Q. 183. Could they roll such a column in sections, as shown in Exhibit I?

78 A. No, sir; they have no rolling-apparatus.

X-Q. 184. What rolling-mill does the work for the Keystone Works?

A. The Union Iron-Mills, of Pittsburg.

X-Q. 185. Could the Union Iron-Works, with their present machinery, roll a column in two sections, as shown in Exhibit H?

A. I do not know; they have no rolls of that particular shape. I do not know what they could do if they had.

X-Q. 186. Has that mill an engine of sufficient power for that purpose?

A. I think it would depend on the length of the piece required, whether or not their power is sufficient.

X-Q. 187. Supposing the column to be twelve feet long, have they the power to do the work for that size?

A. I cannot answer.

X-Q. 188. Do you know what the power of their engine is?

A. I do not know.

X-Q. 189. Do you know the diameter of its cylinder?

A. I do not recollect what it is.

X-Q. 189½. Do you know what the length of its train is?

A. I should think that the length of the bed-plate for the train is about fifty feet.

X-Q. 190. What is the largest diameter of finishing-rolls they have?

A. I think they are twenty inches.

X-Q. 191. Would there be any difficulty in that mill rolling this column in sections of an eighth of a circle, as shown in Exhibit I?

A. I think not if they had the rolls.

Re-examination by Mr. Collier:

Q. 192. Suppose you were called on to make a column or post for a bridge or other structure of rolled iron of the diameter as represented by Exhibit H, to wit, twenty inches, would you make such a column of two pieces or more, and if not of two, why not?

79 A. I would not make it of two pieces, because it would be too troublesome and more expensive.

Q. 193. Suppose an order for such a column was given to any mechanic of ordinary skill in this branch of business, of how many pieces, in your opinion, would such column be made—no directions as to the number of pieces being given to the mechanic?

A. In that case a mechanic would be governed by the dimensions of his machinery to manufacture with.

Q. 194. Is it not usual for persons engaged in this branch of business to regulate the number of pieces by the capacity of their machinery to make them?

A. Yes, sir.

Q. 195. What were the respective positions held by you and Mr. Linville in the Pennsylvania Railroad from 1860 to 1862?

A. Mr. Linville was resident engineer of the middle division of the Pennsylvania Railroad, and I was the master-carpenter. Mr. Linville had his office at Altoona.

Q. 196. To whom did you report respecting your duty as to work in your charge?

A. To J. H. Linville, the resident engineer.

Q. 197. Were you in the office of Mr. Linville frequently during that period?

A. I was.

Q. 198. Was Edward E. Craeger in the same office during this period of time?

A. He was.

Q. 199. Did you see the official correspondence of Mr. Linville during this period of time, or at any time?

A. No, sir; I did not.

Q. 200. What was, prior to 1860, and is, the usual method of uniting parts of iron structures?

A. Usually by means of rivets or bolts.

Q. 201. Do you know of this method of uniting parts of iron structures having been commonly practiced by passing the rivets or
80 bolts through flanges on the respective parts to be united? If so, mention what kind of iron structures you have known to be so united.

A. In constructing iron vessels and iron bridges, or other structures, where iron rolled with flanges is used, the common or usual way of securing pieces together would be by means of rivets or bolts through the flanges or edges of the pieces.

Q. 202. How long has that method of uniting such pieces been practiced, to your knowledge?

A. A great many years.

Q. 203. Who first made rolls to roll sections of wrought-iron posts for yourself, or the Keystone Bridge Company, such as Exhibit D?

A. The Union Iron-Mills.

Q. 204. When was this?

A. I think rolls were made in 1865 or fore part of 1866; I am not positive which.

Q. 205. Where is the post which was sent by Mr. Reeves to Altoona?

A. It is at Pittsburg, in the possession of the Keystone Bridge Company.

Q. 206. What are its dimensions?

A. It is what I would call eight inches in diameter, exclusive of the flanges; the length, I think, is ten feet.

Q. 207. Where is the testing-machine on which its strength was tested?

A. On the Union Iron-Mills property at Pittsburg.

Q. 208. Does the post exhibit any permanent injury by reason of the tests that were applied to it?

A. The post is bent, I think, about an inch, from the effect of the testing.

Q. 209. Did you test a post such as is constructed at the Keystone Works; and if so, was the test made in the same manner as was the test applied to the Reeves post?

(Objected to as not being the proper subject of re-examination—it referring to a subject not alluded to in the examination-in-chief.)

81 A. I believe that it was, with the exception that the post made at Phœnixville had cast-iron shoes or bases upon the ends of it; whereas the post made by the Keystone Bridge Company had none.

Q. 210. Were the tests made with the same machine?

A. Yes, sir.

Q. 211. What *was* the length and diameter of the Keystone Bridge Company's post?

A. The length, I think, was about seventeen feet six inches, and the diameter was eight inches, without reference to flanges and the swell.

Q. 212. How was this post affected by the test?

A. Under a pressure of fifteen tons to the square inch of section I think it was shortened between a sixteenth and an eighth of an inch; but it regained its original length upon removing the pressure; it was not otherwise affected.

Q. 213. Who recorded those tests?

A. Walter Katte.

Q. 214. At the time of your application for the patent of 1865 did you

know that Samuel J. Reeves had obtained letters-patent for a wrought-iron post?

A. I did not.

Q. 215. When were you first informed of the existence of such patent—whether before or after the obtaining the issuing of the patent of 1865 to Linville & Piper?

A. The first information I had that Mr. Reeves had the patent for wrought-iron post was in latter part of summer or fall of 1866, after our patent of 1865 was issued.

Q. 215½. Are not railroad-bars and other forms of rolled iron, in which there is inequality in the thickness of the posts, exposed to the open air to cool after coming red-hot from the rolls?

A. They are.

Q. 216. Are they permanently injured by unequal shrinkage of the parts?

A. I have never known of any complaints being made on that point.

82 Q. 217. I understand you to have stated that the Union Iron-Mills make upset-links for bridges for the Keystone Bridge Company, and which are used by the Keystone Bridge Company; am I correct?

A. Yes, sir.

Q. 218. Will you state wherein, if at all, the process by which they make them, and the machinery or mould in which they are made, differs from the process and the mode by which they were made, in the machine invented by yourself and Mr. Linville, 1861–2, at Altoona?

A. The machine is a much heavier one than they had at Altoona. The dies are similar to the one we had at Altoona. They get their power by means of a cam or eccentric, and a wedge.

Q. 219. How about the follower of the two machines; do they differ in this respect in principle, or are they the same?

A. They are in principle the same as used at Altoona.

Q. 220. Does the Keystone Bridge Company make links by the same process as employed by Linville & Piper in 1861–2 at Altoona?

A. We make links in dies of the same pattern as used at Altoona, but use a different mode of applying power.

Q. 221. Were the chords or links for the Steubenville bridge, which were made by the Phœnix Iron Company, completed ready for drilling at the time of their delivery by the Phœnix Iron Company, or did they require extra work to be done on them?

A. They were not completed ready for drilling; they had to be forged down in thickness and trimmed off to their proper size.

Q. 222. Where was this work done, and by whom, and at whose expense, and what was the expense?

A. It was done at Pennsylvania Railroad Company's shop at Altoona, under the superintendence of George Hawkesworth. At whose expense I do not know; neither do I know the exact cost; I think between one dollar and one dollar and a half per link was the cost.

J. L. PIPER.

83 Sworn and subscribed before me this third day of November, 1869.

JOHN RODGERS,
Examiner.

NOVEMBER 9TH, 1869.

Present: Mr. Collier, for complainants; Mr. McMurtrie, for defendants.

ENOCH LEWIS, a witness produced on part of complainants, being first duly cautioned and affirmed, deposeth and saith:

Question 1. Where do you reside; and what is your occupation; and what was your occupation during the years 1860-1-2?

Answer. Philadelphia; purchasing agent of the Pennsylvania Railroad. From April 1st, 1860, until December 31st, 1865, I was the general superintendent of the Pennsylvania Railroad.

Q. 2. Are you acquainted with the construction of iron bridges and of the several parts composing such structures; and if so, what has been the sources of your information?

A. Iron bridges of several kinds were built during my term of office by the Pennsylvania Railroad Company, at its shops in Altoona, directly under my observation.

Q. 3. Did you have knowledge, at the time of its construction, (1861,) of the building of the bridge (under the superintendence of Jacob H. Linville) over the Schuylkill River, near the arsenal, in this city—which bridge is represented by the model now before you marked Exhibit F?

A. Yes, sir.

Q. 4. Did you see the drawings made by Mr. Linville, or made under his instructions, for the erection of said bridge and prior to its erection?

A. Yes, sir.

Q. 5. About what time was this?

A. I can't fix the date; I should think about the year 1861.

84 Q. 6. Do you remember to have had a conversation with Jacob H. Linville relative to the wrought-iron hollow posts or columns for that bridge at the time referred to, and as to the subject of flanges on the posts; and, if so, will you please state what was said in such conversation?

A. I do remember such conversation; and that I asked the question why the posts in his plan had the two halves secured by rivets through the body, instead of being fastened by rivets through flanges where the edges come together; and the explanation being given that it was made as shown in the model, in order to pass diagonal rods through the body without cutting it and thus weakening it.

Q. 7. From the conversation had by you with Mr. Linville at the time referred to, did he, Mr. Linville, in your opinion, have knowledge of the making and use of flanges on wrought-iron posts, and the fastening of the pieces or parts of posts by means of such flanges, or did he seem to be ignorant of the employment of flanges for that purpose?

A. I should think he had such knowledge. The matter was spoken of and referred to by me as a familiar method of fastening two pieces of iron together, and it did not occur to me, nor was it spoken of, as a new device.

Q. 8. Calling your attention to the model, Exhibit F, and to the fact that the posts shown therein are in two parts, and upon the supposition that such posts were composed of four parts instead of two, will you please state whether such four-part posts would be substantially the same or different in principle and effect as the two-part posts shown in said model?

(Objected to—the witness not being shown to be an expert.)

A. The form of the construction would be different—the effect pro-

duced would be substantially the same; something, of course, would depend upon the form of the four parts referred to.

Q. 9. Did you ever know or hear of the construction of a wrought-iron hollow post for bridges, composed of pieces of iron rolled especially for the purpose, prior to the erection of said arsenal bridge?

85 A. I did not.

Q. 10. How was the post so constructed regarded among that class of persons especially interested in bridge-construction, so far as your knowledge extends?

A. It was regarded as a great improvement.

Q. 11. What are the prominent defects in cast iron hollow posts, and the mechanical difficulties in making such posts of uniform thickness and strength?

A. The uncertainty as to the thickness of the metal throughout and as to its solidity and freedom from blow-holes—the mechanical difficulty which always exists in retaining the core of a hollow casting in its position when the metal is poured into the mould.

Q. 12. Have you personally worked in iron, and are you practically acquainted with iron manufacture and the manufacture of iron structures?

A. I have so worked, and am so acquainted. I learned the business of locomotive-building, and have been connected with the building and working of locomotives and railway-machinery for thirty years.

Q. 13. Upon the hypothesis that, in 1860 or 1861, a pencil-sketch of a wrought-iron hollow post, composed of two or four pieces, with flanges upon the edges of such parts, had been exhibited to you, what other information, if any, would have been necessary to have enabled you to manufacture a post so constructed?

A. Nothing more than the sizes wanted—say the length, width, and thickness of the pieces so shown.

Q. 14. Had you been asked to make a cylindrical hollow post—say eight inches diameter, ten feet long, composed of four pieces, quarter-circles each, with flanges on their edges, metal one-quarter inch, no drawing being exhibited—would you have been enabled, from such description, to have filled such order?

A. As it appears to me now, I think I would.

Q. 15. Did you have knowledge, at the time of its construction,

86 (about the commencement of the year 1862,) of an upsetting-machine said to have been made under the directions of Jacob H. Linville and John L. Piper, at Altoona, and which Exhibit E, now before you, purports to represent?

A. I did have knowledge of such a machine.

Q. 16. Did you see it in operation; if so, when, and how did it operate?

A. I saw it in operation about the time named, and it appeared to accomplish its work well.

Q. 17. What kind of work did you see performed by it, or in it?

A. The upsetting of the ends of rods or links for lower chords of iron bridges.

Q. 18. At whose expense was the machine made, whom did it belong to when made, and under whose authority was it made?

A. I think it was made at the expense of the Pennsylvania Railroad Company—belonged to it, and was made by my direction.

Cross-examination by Mr. McMurtrie:

X-Q. 19. You have spoken of certain drawings in reference to the plan of the arsenal bridge; do you know where they are?

A. I do not know of my personal knowledge, but presume they are in the possession of the chief engineer of the Pennsylvania Railroad; I think they were the working-drawings from which the bridge was constructed.

X-Q. 20. Do I understand you to say that, at the time of the construction of the arsenal bridge, you had never seen wrought-iron posts of any description used for bridges?

A. I do not remember an instance.

X-Q. 21. Do I understand you to say that the use of wrought-iron posts in the construction of bridges was a novelty at the time of Mr. Linville's use of them on that bridge?

A. I do not know that it was a novelty, but I had not seen it so used; they were a novelty, so far as my experience went.

X-Q. 22. Had you never seen either posts, top-chords or bottom-chords composed of more than two pieces of wrought iron, either T-
87 shaped or L-shaped bars, fastened together, back to back, or separated with distance-pieces and fastened together, prior to the exhibition of the plans by Mr. Linville that you have mentioned?

A. I have seen boiler-plate bridges, in which the chords and ribs were fastened together by angle-bars, but do not remember to have seen, prior to that time, the particular form of construction described referred to in the question.

X-Q. 23. When did you first see, if ever, a wrought-iron post composed of two pieces with flanges?

A. I do not now remember to have seen such a post.

X-Q. 24. When did you first see a wrought-iron post composed of more than two pieces with flanges?

A. I cannot fix the time nor the place.

X-Q. 25. Were you at the Altoona works of the Pennsylvania Railroad in the summer of 1863?

A. I was.

X-Q. 26. Did you ever see two wrought-iron columns which were sent there from the Phœnix Works in June, 1863?

A. I do not recollect to have seen them.

X-Q. 27. Do you know the depot at the corner of Fifteenth and Market streets, in this city; are you familiar with it?

A. I know the depot; I am not particularly familiar with its construction. I have not noticed the columns used in its construction.

X-Q. 28. Referring to your answer to the eighth question, would columns composed of four pieces and columns composed of two pieces be the same as to the capacity of their application in the construction of a column or in the facility and economy of the mode of making the parts?

A. I meant to say that a column might be made for the same purpose, and to produce the same effect, either of two or four parts, without entering into the question of the economy of its construction, or in regard to its mode of application.

X-Q. 29. You have said that a similar effect would be produced by making a column of four parts, or of two parts, as represented by Exhibit F. Would the same effects that you have referred to be produced by rolling a hollow column of one piece?

88 A. The column in one piece could be made to give the same support as one made in four or two parts. In my answer to question 8, I meant that a column used, as shown in Exhibit F, could be made for the purpose required, either of two or four parts. A column made of one piece could not be used in that place and in the same

manner, without cutting a hole through it for the passage of the diagonals, which would weaken the post.

X-Q. 30. You have said that if a sketch of a section of the column had been furnished you, with its dimensions, you could have made such a wrought-iron column, and you have also said that Mr. Linville's proposed post for the arsenal bridge was looked upon as a novelty and an improvement; state, then, in what particulars this plan of Mr. Linville's was considered a novelty and an improvement.

A. In the use of wrought iron in the place and in the manner shown in the drawing referred to and in the model, Exhibit F.

X-Q. 30½. I wish you would point the particulars which you intend to be included in your last answer.

A. In the use of a hollow wrought-iron post, in place of a cast-iron one, as before referred to, and in the form of construction which admitted of the passage of the diagonal without weakening the post.

X-Q. 31. Look at Exhibits D and G, and state in what do the improvements or the novelties of those posts consist as compared with the posts in Exhibit F.

A. They differ mainly in being constructed of four pieces instead of two, and in being fastened together at the edges by rivets through flanges, instead of by rivets through the body, as in the other case.

X-Q. 31½. Are any, and which, of these differences improvements?

A. The fastening by rivets through the flanges I think is an improvement, or better than the other method.

X-Q. 32. Is the use of a greater number of pieces than two an improvement, either as respects the column itself, or as to the mode of manufacturing the sections?

89 A. I do not know that it is in the column itself. As a matter of convenience, in handling the pieces in constructing the column, it might be. It would be more convenient also in manufacturing the section.

X-Q. 33. What experience have you had in rolling-mills that would enable you to state the relative facility or expense of rolling iron in different forms or sizes?

A. I have not had sufficient experience to enable me to give the information specified.

X-Q. 34. Are you, then, competent to say what is the value or importance, so far as respects the manufacture in the rolling-mill, of the suggestion to compose the column of more than two pieces?

A. Not so far as experience in manufacturing goes.

X-Q. 35. Was the Steubenville bridge built of cast-iron columns?

A. Yes, sir.

X-Q. 36. Why were not wrought-iron columns used?

A. I don't think I know certainly.

X-Q. 37. Was that bridge designed after the arsenal bridge was built?

A. I think it was.

X-Q. 38. Why were columns such as those used in the arsenal bridge not used on the Steubenville bridge?

A. I do not know.

X-Q. 39. Are you a stockholder in the Keystone Bridge Company?

A. I am.

ENOCH LEWIS.

Subscribed and affirmed to this ninth day of November, 1869.

JOHN RODGERS,
Examiner.

MARCH 11TH, 1870.

Present: R. C. McMurtrie, esq., for defendant; C. B. Collier, esq., for plaintiff.

90 JACOB H. LINVILLE, a witness for the complainants, being duly sworn, deposeth and saith:

Question 1. Where do you reside, and what is your occupation?

Answer. I reside in Philadelphia; my occupation that of a civil engineer, and am specially engaged in the construction of iron bridges.

Q. 2. Where did you reside, and how were you employed, from 1860 to 1864, inclusive?

A. I resided at Altoona, and was the resident engineer of the middle division of the Pennsylvania railroad, and afterwards engineer for buildings and bridges for the Pennsylvania railroad and its dependencies.

Q. 3. How long have you been specially employed in designing and constructing iron bridges?

A. Since 1857.

Q. 4. What was the usual form of iron posts for iron bridges, and of what material were they generally constructed, prior to your invention of wrought-iron posts, such as described in your patent of January, 1862?

A. Round, square and octagon hollow posts of cast iron, and, in some instances, I-shaped posts of cast iron, were generally employed in this country. In Europe, where wrought-iron bridges were in general use, stiffening-ribs of T-irons and angle-irons were used, riveted to webs of plate-girders, and as diagonal ties and struts of lattice bridges.

Q. 5. State what defects, if any, pertain to cast-iron columns or posts for buildings, bridges, &c., and what object was had in view by yourself and John L. Piper in making the inventions patented to you in January, 1862, and October, 1865.

A. Cast-iron posts are brittle; are liable to flaws, honeycomb, air-bubbles, cold-shot, and numerous other defects. Hollow posts are liable to be of unequal thickness of metal, and are easily broken by sudden shocks or in consequence of ice freezing in them. In consequence of the numerous accidents resulting from these defects when used
91 in buildings or bridges, Mr. Piper and myself desired to substitute wrought iron for posts, in such form that we might obtain greater strength with a less amount of material, and thereby increase the security of our structures without increasing their cost.

Q. 6. Calling your attention to the columns as described in said patent of January, 1862, will you state when the same were invented, and when and where first applied in a bridge or other structure?

A. This form of column was invented in the winter of 1860, or early in 1861. It was first applied by us in the construction of the Schuylkill bridge near the United States arsenal.

Q. 7. Calling your attention to the column as described in your patent of October, 1865, will you state when the same was invented, and when and where first applied by you in a bridge or other structure?

A. The shaft of the column, as described in the patent of 1865, was invented early in the summer of 1860, previous to the preparation of the drawings, Exhibits A and B of Crueger's testimony. That form of shaft was first applied by us in the construction of an iron span in the bridge over the Susquehanna River at Dauphin in the early part of 1866.

Q. 8. Will you state why you employed the form of post as described in your patent of 1862, and not that as described in your patent of 1865, in the construction of the Schuylkill arsenal bridge?

A. To answer this question properly will require some preliminary

statements. Early in the summer of 1869, the chief engineer of the Pennsylvania railroad advised me that he would advertise for plans and proposals for the bridge over the Schuylkill River, and he desired me to prepare plans and estimates and submit them on the part of the engineer department of the road. Mr. Piper and myself began considering the subject of wrought iron posts to be substituted for cast-iron in bridge-construction. We designed and delineated numerous forms of posts composed of two and four pieces, with flanges on their edges, and
92 united by rivets through the flanges, forming circular hollow posts and other geometrical figures. We also designed hollow posts of four angle-irons; posts of four T-irons. These designs were not made with special reference to the Schuylkill bridge, as we did not suppose that we would be able to compete with other parties who would probably propose for the bridge with cast-iron posts, if we used a new form of post and combination of wrought iron for that bridge, nor did we suppose that a wrought-iron post would be accepted for that bridge, except, perhaps, for the pivot span. I had prepared, among other drawings, two drawings marked Exhibits A and B of Crueger's testimony, before referred to. Exhibit A represents a plan for a permanent span, with cast-iron posts and upper chords; Exhibit B a drawing for a pivot span, in which the post is represented as being made of four angle-irons, and wrought iron upper and lower chords. These plans were submitted to J. E. Thomson, the president of the Pennsylvania Railroad, in December, 1869. Mr. Thomson approved of the plan, Exhibit A, and adopted it for the Schuylkill bridge, substituting for cast-iron posts, as shown in the drawing, wrought iron posts, and suggested substituting a post composed of four angle-irons, such as are shown in Exhibit B, the drawing for the pivot span. While these drawings were before Mr. Thomson, the subject of wrought-iron posts was discussed between us, and I informed him that Mr. Piper and myself had invented a form of hollow cylindrical post, four pieces of iron riveted together through flanges, which I thought would be lighter and stronger than the angle-iron post, and harmonize better with the general feature of the plan as adopted. Mr. Thomson coincided with me in opinion, and entrusted to me the adoption of a post that I thought would best conform to the architectural appearance and characteristics of the bridge. The Exhibit A having beeen adopted, my attention was turned to the best form of post to be adopted in the structure; and in making the working drawings in the winter of 1869, and early part of 1861, I first had drawn a post composed of four quarter circular discs, with flanges on
93 their edges, and rivets passing through the flanges, and through interposed ferrules, producing a swelling of the posts. This post was similar to the one sketched by Piper and myself in the summer of 1860. This was drawn on a smaller scale, and showed a complete elevation and section of a post. With this exception—that that post was straight, not swelled—we afterwards demonstrated the advantage of swelling the post. As the working drawings progressed, I discovered that the suspension bars were so situated in design for that bridge as to interfere with and cut the flanges near the centre of the post, the post being similar to Exhibit G of Piper's testimony. The cuts in the flanges show the portions of the flanges that would have been cut away by the suspension bars, unless I spread the suspension-bars further apart, thereby increasing the width of the upper chords, the widths of the bases and capital of the post, and thereby considerably increasing the cost of the structure, so as to exceed my estimates. I found, further, that as I intended at that time to cast the bases and capitals around the

posts, I'd be compelled to cut the flanges away at the ends of the post, thus weakening the shaft at this point, or, on the contrary, would have been compelled to make the bases and capitals much large than I intended. It was then suggested to omit entirely the flanges on two sides of the post adjacent to the suspension-bars, making the post of two semicircular discs, with flanges on the edges, and rivets passing through the flanges, and interposing ferrules of varying lengths, swelling the post in one direction only. This form of post would have permitted the passage of suspension-bars without necessitating the increase in width of upper chords, bases, and capitals of post. But this form was otherwise objectionable; the diameter in one direction would have been greater than the diameter in the other direction, and the post would not have been of uniform lateral stiffness, nor would it have presented a pleasing appearance in the bridge. After fully canvassing all the different forms of posts, and considering first cost, general convenience, and architectural effect, I determined to omit the flanges entirely, and substitute two semi-cylindrical discs, united by rivets passing
94 through the body of the discs and interposed distance-pieces.

I made a tracing of a section of this form of post and sent it to Charles E. Smith, then proprietor of the Fairmount Iron-Works. He came to Altoona, and objected to this form of post because it was not sufficiently angular to be guided through the grooves in the rolls. We discussed various forms of posts with flanges, of two or more pieces, which he desired to roll in preference to the two plain circular discs without flanges. I objected to the use, in this bridge, of all these forms for reasons previously stated; and Mr. Smith finally agreed to roll the bars for the posts of two semi-octagonal discs or shells, such as is shown in model of the post of the arsenal bridge, Exhibit F. We then proceeded to complete the working drawings, and made the drawing, Exhibit C, which represents a wrought-iron hollow post, composed of two semi-octagonal discs united by rivets passing through the body of the post and through distances-pieces, and also showing ornamental cast-iron capitals and bases cast around the body of the post, the flanges having been omitted for the reasons previouslystated. The post of the bridge was constructed according to this drawing, Exhibit C.

Q. 9. Look at the drawing now before you, and marked by the examiner "Linville 1," and state by whom it was made and what it represents.

(Here follows diagram marked page 96.)

A. This drawing was prepared under my direction, to illustrate the different forms of posts referred to in my previous answer, and also some other forms of posts which will be hereafter referred to. The drawings show a section and an elevation immediately opposite the same of the different forms of posts indicated by the numerals. Figure 1 represents a section and elevation of a hollow post, composed of four quarter circular discs, with flanges on the edges of each, and united together by rivets passing through the flanges, and is the same form of post delineated by Piper and myself early in the summer of 1860, at which time we made sketches of elevations and sections of the post and method of combining the parts together by rivets through the
95 flanges. Figure 2 represents a post composed of four pieces of iron of the same section as shown in Figure 1, but united by rivets passing through the flanges and interposed ferrules, forming a swelled post similar to Exhibit G, and represents the post similar to the one which was first drawn in the working drawings for the Schuylkill arsenal bridge. On two sides of this section, Figure 2, are shown the

suspension-bars, in the same relative position to the post that they would have occupied in the drawings referred to for the Schuylkill bridge, showing that the suspension-bars would have interfered with the flanges on two sides of the post, as stated in my previous answer. In consequence of the interference of the suspension-bars with the flanges, we next proposed a post similar to Figure 3, which shows a section and elevation. This form was objectionable because it was not of equal diameter in both directions, and we next adopted a form of post as shown in Figure 4. On consulting Charles E. Smith, he objected to this form in consequence of difficulties in manufacture; and the form of post as shown in Figure 5 was then substituted, according to which the Schuylkill bridge was constructed. In consequence of the omission of the flanges, the rivets were passed through the body of the post; and these figures, 1 to 5 inclusive, are intended to show some of the different forms of hollow posts, of two and four pieces, that we invented and delineated during the summer of the year 1860. Figure 6 represents a peculiar form of post, composed of four peculiarly-shaped angle-irons, with extra flanges on each edge, united by rivets through the flanges, forming a hollow swelled post. Figure 7 represents a hollow post, composed of four angle-irons riveted through flanges and through interposed distance-pieces—the last two figures having been designed by us in the summer of 1860. Figure 8 represents a post composed of four peculiarly-shaped angle-irons, united by rivets passing through the flanges and through flat bars which extend from the exterior of the flanges and meet at the centre of the post. Figure 9 is composed of peculiarly-shaped angle-irons, similar to Figure 8, riveted through the flanges, the flat bars shown in Figure 8 being omitted. It is also
97 a correct representation of Figure 4 on the drawings attached to the patent of Samuel J. Reeves of June 17th, 1862. Figure 10 represents a cruciform solid post, composed of four angle irons riveted through flanges and through flat bars meeting in the centre. It is similar to struts that have been in bridges in Europe, described in published works previous to 1862. Figure 11 represents a cruciform swelled post, composed of four angle-irons riveted through flanges and interposed ferrules. The posts, sections, Figures 10 and 11, differ from the post, Figure 7 in this, that in Figures 10 and 11 the angles are turned towards the centre, forming a solid post, while in Figure 7 they are turned from the centre, forming a hollow post.

Q. 10. State what, if any, feature or characteristic in common pertains to posts such as shown in Figures 1 to 9 inclusive.

A. As I have stated in answer to a previous question, the same general feature belongs to each and all of the forms of posts, 1 to 9 inclusive, in that the material forming the post is spread away from the centre, thereby forming a hollow post and securing greater strength than can be obtained by the forms Figures 10 and 11. Figures 1 to 9 differ from each other in other respects, as in geometrical figure and otherwise, and also in the mode of attachments. These differences do not affect the principle—the object in all being to secure increased diameter, or the greatest diameter possible, and thereby to secure increased strength, or the greatest possible strength with the least possible material. In some cases it is more convenient to unite pieces by means of rivets passing through the flanges, whilst in other forms it is more convenient to omit the flanges and combine the parts by rivets passing through the body of the post. When the post is small it is more convenient to roll it of two pieces, and when the post is large it is

more convenient to roll it of a larger number of pieces, and of such a number as can be readily rolled in such rolls as are in ordinary use.

Q. 11. Wherein, if at all, do said posts (Figures 1 to 9 inclusive) differ from posts, Figures 10 and 11, in principle?

98 A. The difference is this: taking a given weight of material and forming of it, in one instance, a solid post, as in Figures 10 and 11, and in the other instance, hollow posts, as in Figures 1 to 9 inclusive, the latter will be much stronger than the former; for as you expand the material away from the centre towards the periphery, you increase the diameter of the column, and, as the diameter increases, the strength of the column increases in a very rapid progression.

Q. 12. Do you know of the employment of a hollow post, such as described and shown in either of said figures, 1 to 9 inclusive, prior to 1862? or can you refer to any printed publication prior to 1862, in which such printed form is referred to? If so, describe such publication.

A. Posts similar to Figure 8 were used in the grain-warehouse connected with the military bakery in Paris. I now refer to "Allgemeine Bauzeitung," by Foster, printed in Vienna in 1861. I refer to text as found on page 215, in the September number, 1861. "Columns A A, plate 437, built of cut stone, and connected together by brick arches, support wrought-iron columns A A at distances of 3.36 metres apart, and which extend to the entire height of the building. These iron columns, the cross-sections of which are represented on page 440, Figure 5, K G, consist of a wrought-iron plate, 0.3 metres wide, by 12 millimetres thick, united by means of peculiarly-shaped irons with flanges—thus connected to produce in the centre of the combination hollow spaces, by reason of which the rigidity of the column is increased, while the area of the cross-section remains such as is necessary in relation to the resistance to compression." I also refer to said work, plates 437, 438, columns A A, H H, N N; also, plate 440, sections F, G, H, K.

Q. 13. Calling your attention to Figures 4 and 5 of Exhibit "Linville 1," will you state what difference, if any, there would be, in principle and effect, between columns of that construction, of wrought-iron pieces formed of two pieces on the one hand, and of four on the other?

99 A. I do not consider that there would be any difference, either in principle or effect, if formed of two or four pieces.

Q. 14. Applying the same question to figures 1 to 9, inclusive, is the same statement as contained in your last answer equally correct, or is it incorrect?

A. It is correct. The answer that I have given to the former question would be substantially the answer to this question—that one general feature distinguishes forms 1 to 9 from figures 10 to 11; the material in figures 1 to 9 being spread away from the center to form a hollow post, while in figures 10 and 11 the material is disposed near the centre, forming a solid post.

Q. 15. Do you find anything in the letters-patent of Samuel J. Reeves of June 17, 1862, relative to the point under consideration? If so, state what you there find, and also whether what you may there find accords with your own opinion or differs therefrom.

A. I find in the patent of Mr. Reeves a statement as follows: "I use three or more wrought-iron bars similar to those marked *a a a* in the annexed drawing," &c. In the drawing attached to the patent of Mr. Reeves no post of three pieces is shown. I regard the words as quoted as being a statement that the same effect would be produced whether the post was made of three parts or six parts, instead of four parts, as

shown in the drawing. This accords with my own opinion, and the same, I think, would be equally true if only two pieces were used.

Q. 16. State how the posts, as employed by you in the Schuylkill arsenal bridge, (such as model F, Crueger's testimony, and figure 5, Linville's testimony,) have answered the purpose for which they were intended, and has the strain upon them been great or light?

A. This bridge was finished early in 1862, and since that time has been subjected to the strains resulting from heavy railroad trains; the post has answered its purpose perfectly, and is in perfect condition at the present time.

Q. 17. Are you able to state, from actual observation, and, if so,
100 will you state, what has been the effect or result of the means of attachment of the different parts of your post, as described in your patent of January, 1862, and as employed in said Schuylkill arsenal bridge?

A. Our object, of course, was to so combine the parts as to secure unity and conjoint action of the parts composing the post. I have frequently seen these posts when under the action of heavy strains resulting from the passage of heavy trains, and am able to state that the methods there employed have answered the purpose for which they were designed perfectly.

Q. 18. Look at the photographs now produced, and marked by the examiner Exhibits "Linville 2 and 3," respectively, and state what the same represent.

A. Exhibit 2 represents the wrought-iron bridge over the Schuylkill River in Philadelphia, usually called the "Connecting railway bridge;" it was constructed under our patents, and erected by the Keystone Bridge Company. Exhibit 3 represents an interior view of the wrought-iron bridge built by the Keystone Bridge Company under our patents over the Mississippi River at Dubuque, and called the Dunleith and Dubuque bridge.

Q. 19. Have you introduced your patented improvements referred to extensively or otherwise?

A. We have introduced them very extensively in most portions of the United States. We have constructed, are constructing, or are preparing to construct, bridges over the Mississippi River at Dubuque and Keokuk; over the Ohio River at Steubenville, Bellair, Parkersburg, and Cincinnati; bridges on the Pittsburg, Cincinnati, and St. Louis Railway; Terre Haute and Vandalia and St. Louis Railway; Pittsburg, Fort Wayne and Chicago Railway; the Pennsylvania Central Railway; on the Northern Central Railway; on the Lehigh and Susquehanna Railway, across the Delaware and Lehigh Rivers, and elsewhere; on the New Jersey Railway and Transportation Co.; on the New Haven, Middletown and Willimantic Railway, over the Connecticut River at Middletown; on the New Orleans, Mobile and Chattanooga Railway; and elsewhere.

Q. 20. When were you first advised, or did you have knowledge,
101 of the execution of the letters-patent issued to Samuel J. Reeves on the 17th June, 1862?

A. Not until after the grant of the patent to myself and J. L. Piper, in 1865. I was first informed by Mr. Reeves in the winter of 1865–'66. I did not know previous to this time that Mr. Reeves had applied for or obtained a patent, and our attorney, who obtained for us the patent of 1865, informed us that he had examined at the Patent-Office and could not find any patent on posts or columns to Samuel J. Reeves. In January, 1863, I received a letter from Mr. Reeves, in the postscript to

which he says: "I would particularly call your attention to our new plan of making wrought-iron columns or posts for bridges as admirably adapted to your Steubenville bridge. I am satisfied that you will find them both cheaper and better than cast-iron columns; for trussing they are particularly convenient. Mr. Wilson promised me he would see you and explain the mode of putting these columns together." Subsequent to the receipt of this letter I had an interview with Mr. Wilson, when he showed me the form of post proposed by Mr. Reeves. I distinctly said to him at once that that form of post was covered by our patent, that we had invented the hollow wrought-iron post, and that that post was covered by our patent of 1862. Some time after this interview, in the summer of 1863, I saw at Altoona two specimens of posts made by the Phœnix Iron Company. As soon as I saw these posts I said to different persons that these columns were an infringement on our patent of 1862; that we were the original inventors of a wrought-iron hollow post similar to that, and that that post was covered by our patent. (The letter referred to from Mr. Reeves is here produced and marked by the examiner "Linville No. 4.") I wrote to Mr. Samuel J. Reeves, March 21st, 1864, a letter, of which the exhibit marked "Linville No. 5" is a true copy, the original having been destroyed at a fire in my house. At the time of writing this letter I thought perhaps that Mr. Reeves had a patent on the mode of
102 forming the "pile or billet" from which the post bars were rolled, or a patent on some peculiar form of rolls, or rolling the bars, just as I believe there is a patent on the method of forming the "billet or pile" and rolling I beams, as practiced at the Phœnix Iron Company's works, and my object in writing this letter was to elicit information. At the time this letter was written I was engineer, employed by the Pennsylvania Railroad Company to construct the Steubenville and other bridges. The Keystone Bridge Company had not at that time been organized, and I had no means of getting such posts as were asked for, except from persons having rolling-mill facilities. Mr. Reeves responded to this letter of March 21st, 1864, giving prices, &c., but did not respond to my inquiry whether there was a "patent on the manufacture." Of the use of the "posts" and "up-set chords" referred to in my letter, I believed we had the exclusive monopoly. The letter of Mr. Reeves referred to was burned at my dwelling last October, and I have no copy.

MARCH 17TH, 1870.

Met pursuant to adjournment.

THE LOWER CHORDS.

Q. 21. Calling your attention to the lower chords, as claimed in the first claim of your patent of 1862 and the third claim of your patent of 1865, and to the references as contained in the answer of the Phœnix Iron Company and others to the use, prior to said patents, of lower chords of alleged similar character, will you point out wherein such references are like or unlike the chords as described and claimed in your patents respectively?

A. In the patent of 1862 we describe and claim "lower chords of truss bridges of a series of wide and thin drilled eye-bars C C, applied on edge
between ribs S S on the bottom of the post, and connected by
103 pins P P, supported in the diagonal tension-braces D D and E, substantially as described." In the answer of the defendants

reference is made to a printed work entitled "Papers and Practical Illustrations of Public Works," &c., published in England by John Weale, in 1856, and to plate 10 of drawings of Newark dyke bridge of said work. The reference in this work I have carefully examined, and I think there is a substantial difference between the chords as employed in that bridge and as described and employed in our patent of 1862. In both the chords are made of thin wrought-iron eye-bars, placed on edge, and so resemble each other in configuration; but the respective combinations are not the same, inasmuch as the chords in the Newark dyke bridge are not applied between ribs on the bottom or base of the post, while in our patent they are so applied. These different applications and combinations produce very different results. In the combination as employed in the Newark dyke bridge, for example, the strains caused by the suspension diagonals and lower chords is exerted on the ends of the pins, while at the same time the posts bear on the centre of the pins, and so, under heavy weights, will bend or tend to bend the pins; while in our combination, the strains of the diagonals, lower chords and posts, by the intervention of the ribs, are distributed along the entire length of the pins, which are accordingly capable of resisting, without danger of breaking or bending, a much heavier strain. In our patent of 1865 we claim "the use for the lower chords of truss-frames of wide or thin-rolled bars with enlarged ends, formed by upsetting the iron, when heated, by compression into moulds of the required shape, for the purpose of increasing the density, toughness," &c. So far as the claim of this patent is concerned, I cannot see that the reference of the defendants has any application whatever, since there is no suggestion whatever in the work of "Weale" descriptive of the lower chords of Newark dyke bridge, that they were made by the upsetting process, or by any other mode than the ordinary mode in use at that time, which consisted in enlarging the ends by the well-known process of forging. In
104 the other reference of the defendants, the links described therein were enlarged at the ends by the patent of Messrs. Howard & Ravenhill, by passing them sideways through the rolls, which is wholly different from the method by which the chords as described in our patent of 1865 are made, and which therein is called the upsetting process.

Q. 22. What do you know relative to the use by the defendants of lower chords for iron bridges? state, if you know, the combination in which the same are employed and the process by which made, and wherein, in such particulars, the same resemble or differ from the lower chords, combined and made as described in your patents of 1862 and 1865 respectively.

A. I saw the bases of the posts as constructed by the Phœnix Iron Company, and intended for the La Salle bridge, in Illinois. These bases had ribs projecting downwards for the insertion of the lower chords, the ends of the chords being intended to be inserted between the same and fastened all the same substantially as described in our patent of January, 1862. I saw at the same time the eye-bars which were intended for insertion between these ribs, and the same had enlarged ends which had been formed by upsetting the iron, when heated, by compression into moulds corresponding in shape to the ends of the chords, for the purpose of increasing their densities, substantially as described in our patent of 1865. I think it was about two years ago that I saw these chords.

Q. 23. How do you know that the Phœnix Iron Company made these bases and chords, and how do you know that the chords were made by the upsetting process?

A. The bridge was being built, to my knowledge, by Charles Kellogg, of the firm of Kellogg & Clark, bridge-builders; and I have knowledge, from Mr. Reeves' conversations and admissions in my office, that the iron work of them was made by the Pœnix Iron Company. I think also that some of the pieces that I saw had the mark of the Phœnix Iron Company on them. The opinion expressed as to the manner in which the lower chords were made—that is, by upsetting—was derived from the inspection of the ends and from my knowledge of the appearance and the marks of the mould on chords so made.

105 Q. 24. Have you read, and do you understand, the description of the process of upsetting chords as practiced by defendants, as testified to by Samuel J. Reeves (answer to question 36 of his testimony;) and if so, state wherein, if at all, such process differs from that described in your patent of 1865.

A. I have read the testimony of Mr. Reeves referred to, and think there is no substantial difference between the defendants' process therein described and as described in our patent of 1865. In our patent we describe the enlarging or upsetting the ends of the chords by compressing them into the desired shape in moulds, into which the heated iron is forced under immense pressure. According to the testimony of Mr. Reeves, the process of the defendants contemplates the heating of the end to be upset or enlarged, and placing this end in a die or mould which is larger than the desired thickness of the chord; pressure is then applied to the chord until its end is made to fill the die or mould; it is then removed, reheated, and placed in another mould or die, which is of the width required for the end when finished; pressure is then applied to this die, and by means of this pressure the heated end is spread or enlarged so as to fill the die or mould. The object sought to be obtained in both is the enlargement of the end so as to permit the holes or eyes for the pins to be made without reducing the transverse sections of the ends of the chord to a less area than that of the body of the chord, and of so accomplishing this by means of pressure as to increase the density and toughness of the metal. Mr. Reeves has not described the means of applying the pressure in the machine used by them, nor the manner by which the box of the machine holding the dies is bound together; but while in such respects there may be a difference between the methods of applying the pressure as practiced by them from the mode as practiced by us, yet in both cases the chords are formed under pressure, and so the chords and the method of upsetting them are, in my opinion, substantially the same.

Q. 25. Look at the machine, Exhibit E, (testimony of Jacob Szink,) and state what it represents, and when and by whom it was invented.

106 A. That machine is the model of a machine invented by J. L. Piper and myself, as constructed at Altoona, under our direction, early in 1862, for the purpose of performing the process of upsetting. The original machine was constructed at the expense of the Pennsylvania Railroad Company, and was and is their property.

Q. 26. Describe the operation of the machine represented by Exhibit E.

A. This consists of a mould or die having a lid which is hinged so as to be capable of being lifted, permitting the insertion of the heated chord, and its removal when upset or enlarged. The machine also embraces a "follower," to the end of which pressure is applied so as to cause the heated chord to spread or fill the mould or die—the lid of the mould being keyed down during the application of the pressure.

Q. 27. Wherein, if at all, does the method of upsetting chords, as described in your patent of 1865, and as practiced by you, differ from the operation as shown in said model, Exhibit E?

A. In no respect, except as to the means of securing the mould or die during the application of the power, and in the fact that the power is applied by means of an eccentric and toggle-joint; whereas in that machine it is applied by means of a screw, (and this was the only difficulty in the working of that machine.)

Q. 28. Calling your attention to the correspondence between yourself and Samuel J. Reeves, as set forth in the answer of the defendants, (pages 14 and 15, printed copy,) will you state whether the same are correct copies of the originals, and also the circumstances attending the writing thereof?

A. The said copies are correct. At this time, January, 1863, the Pennsylvania Railroad Company was engaged in the construction, under my supervision, of the Steubenville bridge, for which larger chords were required than had been employed in any bridge previously constructed under my charge. It was necessary for the Pennsylvania Railroad Company to have the chords made at some manufactory
107 having the required facilities, and I invited proposals therefor from several firms, and among others from the Phœnix Iron Company, through Mr. Reeves, as shown by copy of my letter as found on page 12 of defendants' printed answer. My letter inviting proposals specified "hammered" chords, because the chords were required soon; and I did not know or suppose that there was any upsetting machine in existence other than the one built by J. L. Piper and myself for the Pennsylvania Railroad Company, already referred to; and the die or mould of that machine was not large enough to contain the chords for that bridge, even if we had the power to work it, which we had not. After the receipt by me of the Reeves letter of January 19th, 1863, I went to Philadelphia, and there had an interview in the Phœnix Iron Company's office with George H. Sellers, then superintendent of the Phœnix Iron Company, in which I explained to him fully the mode of upsetting as invented by myself and Piper in the previous year, and explained the difficulty which we had encountered as to the power. Mr. Sellers told me that they would provide at their establishment the requisite power by means of a large hydrostatic press, and I then became satisfied that they would succeed in making or upsetting the chords, and gave the order as contained in my letter of January 28th, 1863. In employing the language contained in that letter—"being satisfied," &c., "according to your process"—I intended nothing more than to express my belief that, with their appliances for getting the requisite power, they would succeed.

THE TOP CHORDS.

Q. 29. Calling your attention to that part of your patent of 1865 which relates to the top chords, and to the printed publications and drawings referred to in the defendants' answer, of alleged similar inventions, will you state wherein the said chords, as patented to you, resemble and differ from those described in said publication?

A. The answer of defendants refers to volume 1, plate A,
108 figure 4, of Humber's work on bridge-construction, as anticipating this claim. The upper chords, as described in the second claim of our patent of 1865, resemble those referred to in no respect except that they consist of a combination of I-shaped rolled beams, or

channel-bars, riveted at the top and bottom to plates of iron, so as to form a series of cells. As to the objects for which the combination is formed, the mode of application, and the combination with the other parts of the bridges or truss-frames, and the numerous economical and useful purposes served by the combination, as described in our patent, I think there is a substantial difference. In the plate referred to in Humber's work is shown a box of I-beams, channels, and plates, which was suggested for the compression-member of a plate-iron girder bridge. The chord or upper flange employed in this manner is shown to be riveted to a continuous plate-iron web, or vertical member, forming the side of the bridge, instead of a construction which consists of a series of independent posts and diagonal rods, as is shown in our model F; and in this combination the chord of the plate-girder would be subjected to compression only. The chords of wrought-iron I-beams, channels, and plates, as shown in our model, Exhibit F, are employed as girders, reaching from post to post, to resist transverse strains, and are employed to support the floor of the bridge and the transverse strains resulting from the weight of trains of cars. They are made in short, independent sections, of one panel in length, and each section is riveted together complete in the shops; and the sections are planed to exact lengths, so as to meet and abut fairly together over each post without any other than the pin-connection. In the plate bridge referred to in Humber's work, the upper flanges are made in one connected piece, and must be riveted together in position in large structures at the bridge site, causing serious difficulty, expense, and delay in the erection; while, on the contrary, our chord, being completed at the shop, can be erected with facility and rapidity, obviating great risk and delay in erecting structures over rivers, or on roads in operation, in place
109 of existing bridges. By the use of such chords, made in short, independent sections, one panel in length, we have been able to dispense with cast-iron chords in skeleton or truss bridges, and to secure more reliable structures without materially increasing the cost of the same. We can erect structures so composed with wrought-iron chords with as great facility as with cast-iron chords.

Adjourned until March 22d, 1870.

APRIL 6TH, 1870.

Met pursuant to adjournment. Mr. McMurtrie and Mr. Collier present.

Cross-examined by Mr. McMurtrie:

X-Q. 30. Were wrought-iron posts of any kind used prior to 1862?

A. They were.

X-Q. 31. Were they used, prior to that time, composed of more than one piece, whether T-bars, angle-bars, or other forms united so as to form one post?

A. I have already stated in my examination that angle-irons, with the angles turned towards the centre, forming a solid cruciform post, as in Figure 10 of my testimony, had been used as posts in bridges prior to 1862. Posts made of two T-irons, taking the place of four angle-irons, forming a cruciform solid post, have also been used.

X-Q. 32. Do you assert that these posts and the forms of posts described in your patent of 1862 are identical or equivalents?

A. They are neither identical nor equivalents, in my opinion.

X-Q. 33. Point out what, in your judgment, are the prominent distinguishing features between the posts as above referred to and the post described in your patent of 1862.

110 A. In the posts above referred to the angles are turned towards the centre of the column, thus forming a solid post; while, on the contrary, in the post covered by our patent, the material is expanded away from the centre towards the periphery, in order to increase the diameter with the same weight of material, and form a hollow post.

X-Q. 34. What is the practical limit of diameter of a post composed of two pieces only, when rolled in the form described in your patent of 1865, and assuming that the edges of the pieces are brought in contact?

A. It would be difficult for me to answer that question definitely, since I have not had occasion to make the inquiry of iron-manufacturers. In all cases where we desired the columns of a larger size than those for which we had rolls, we have increased the number of pieces. Our custom has been to make large columns of eight pieces; we make those columns of nearly all sizes, from four inches to twenty-three inches in diameter.

X-Q. 35. What is the largest column in diameter which you have ever rolled, composed of two pieces only?

A. The Union Iron-Mills have never rolled any columns for us of two pieces. The Schuylkill bridge columns were made by Charles E. Smith, of the Fairmount Iron-Works; he desired to roll these columns in four pieces, but I induced him to roll them in two pieces, as already stated in my direct examination, for the reasons therein stated.

X-Q. 36. What is the largest column composed of two pieces that you have ever procured to be rolled by anybody?

A. We have never asked parties to roll other columns in two pieces except those in the Schuylkill arsenal bridge.

X-Q. 37. Is it not more convenient to roll columns in sections of more than two, or segments less than half circle?

A. If the columns were large it would be more convenient to roll them of more than two sections.

X-Q. 38. At what point of diameter, in your judgment, would it become more convenient to break the column up in sections more than two?

111 A. We determine this by the facilities of the parties from whom we intend to procure the columns. As a general rule, I think a less number of pieces would be an advantage to the parties who secured the parts of the post together, while a large number of pieces would be more convenient and advantageous to the party who rolled the bars.

X-Q. 39. Look at the paper now produced, marked Defendants' Exhibit Linville, No. 1, and state what it is.

A. It is a lithographic card published by the Union Iron-Mills, representing shapes of iron rolled by them; also two elevations of columns, the shafts of which are such as were invented by us in 1860.

X-Q. 40. That is the iron-mill, I understand, that does your rolling?

A. They roll nearly all the shaped iron used by us.

X-Q. 41. I observe on that card no form of iron for composing a post suggested that is greater than a quarter of a polygon; that is so, is it not?

A. There are no forms of iron there intended to form a polygonal post that do not require at least four to make a regular polygon.

X-Q. 42. Did you ever know of that company rolling iron for a round or a polygonal post composed of less than three pieces?

A. I have not.

X-Q. 43. What rolling-mills were consulted for rolling the posts for the arsenal bridge besides Mr. Smith's?

A. I cannot recollect now of having consulted any other mills or any other parties than Mr. Smith.

X-Q. 44. It has been stated that the mill that was consulted objected to the difficulty of keeping the pieces in the rolls.

A. That was so in reference to Figure 4, which represents the first form that I asked Mr. Smith to roll; he made the same objection to rolling the pieces as in Figure 3; he said that forms shown in Figure 3 could be rolled if a rib were placed on the back of the semicircular portion to guide it through the rolls. This rib was objected to by me because it interfered with the suspension-bars.

112 X-Q. 45. Did you show him drawings of sections which were less than half circle, or semipolygonal—that is, quarters, eighths, or sixteenths?

A. I believe sketches of all the forms on Exhibit Linville 1 were made and talked over between him and myself, excepting the polygonal form, Figure 5, and Figures 8 and 11. Mr. Smith rode with me from Altoona eastward, and a great number of forms of posts were sketched and suggested during our interview. Nothing was definitely determined until I sent him sketch figure 5. This form was made angular for the special purpose of guiding it through the rolls. His objection to form Figure 4 was, as I understood, that it would not guide through the rolls, but would work sideways. That was overcome by the angular form of figure 5.

X-Q. 46. Have you a distinct recollection of exhibiting to him, and consulting with him, of the feasibility of rolling pieces as in Figures 1 and 2?

A. I have a distinct recollection that he desired to roll the post of four pieces, similar to Figure 1, in preference to the forms shown in Figure 4. I think this answers this question, because I had drawn the post as shown in Figures 1 and 2, and had rejected the flanges, in the first place on two sides, and subsequently on the other two sides, as already explained in my direct examination, in order to allow the suspension bars to pass by the post, and preserve the symmetry in the form of the column, which reduced the section to the form as shown in Figure 4.

X-Q. 47. Had you made this drawing, as in Figures 1 and 2, and rejected the flanges, and come down to Figure 4 as the plan to be adopted, before you consulted with Mr. Smith?

A. I think the first communication to Mr. Smith in relation to this post enclosed a full-sized tracing of one section of Figure 4.

X-Q. 48. My question remains unanswered. Mr. Piper and Mr.

113 Crueger refer to an interview between yourself and them, in which pencil-sketches of posts were made, and during which interview you objected to flanges, and they were rejected from the proposed plan. What I want to know is, whether that occasion, when the flanges were rejected, was prior to the consultation you had with Mr. Smith on the subject of rolling?

A. The time when I objected to the flanges for use in the Schuylkill bridge was during the preparation of the "working drawings" for that bridge. At that time the idea of making the post of two pieces, without flanges, as shown in Figure 4, had not occurred to me, and consequently it must have been previous to my consultation with Mr. Smith.

X-Q. 49. As you have determined that there should be no flanges on the pieces when you first consulted Mr. Smith about rolling, can you say who it was that, during that consultation, suggested the rolling of the columns in four pieces, with flanges?

A. I think it came about in this way: Mr. Smith objected to rolling pieces that would cut so deep in the rolls, and desired to increase the number of pieces. I gave him my reasons for making the post of two pieces, and during the conversation the other forms of posts that we had rejected for that bridge were mentioned.

X-Q. 50. What was your object in calling Mr. Smith's attention to the forms you had sketched with flanges if you had determined, as you say you had, that you would not have flanges on the pieces to be rolled?

A. Mr. Smith spent a long time in my office. He had with him a satchel containing a large number of templets, T and angle; and we had a great deal of conversation in reference to rolling shapes of iron. During this conversation the different forms were mentioned.

X-Q. 51. Were delineations of those forms exhibited to his eye?

A. I believe they were; also other forms that I have mentioned, and others that I have not mentioned. Mr. Smith also sketched numerous orms, which he desired me to substitute for Figure 4; his object appeared to be to induce me to adopt some form that could be rolled with greater facility than Figure 4.

X-Q. 52. What remark, if any, did he make on the delineation similar to Figures 1 and 2?

114 A. My recollection is that the remark left the impression on my mind that those forms could be readily rolled.

X-Q. 53. Give us, as near as you can, the date of that conversation with Mr. Smith.

A. I have not referred lately to any of the correspondence with Mr. Smith, but it must have been after the 15th day of December, 1860, and prior to the 1st day of April, 1861; I think it was in January, 1861.

X-Q. 54. Point out in your patent of 1862 the words that you think indicate, or were intended to indicate, the use of more than two sections to compose a column.

A. In the specification, "T or L shaped sections" were intended to refer to four pieces. In the claim, "2d, two wrought-iron plates or bars, or their equivalents," which we always considered embraced any number of pieces that would be the equivalent of two pieces.

X-Q. 55. Point out what language, in your patent of 1862, was intended to indicate the use of pieces having flanges.

A. The words "or their equivalents," as referring to the method of combining the pieces. We believed this claim covered a hollow post, formed of rolled shapes of any number of pieces.

X-Q. 56. Point out the language in that patent which will indicate, as the mode of uniting the pieces, the use of rivets through the flanges.

A. The use of rivets through flanges was a well-known device, and was presumed to be covered by the word "equivalents," as previously stated.

X-Q. 57. Do you assert that your post, as described in your patent of 1865, is also described in your patent of 1862?

A. It is more minutely described in the patent of 1865 than in the patent of 1862. The particular form shown in the drawings of the patent of 1865 was invented by us prior to the particular form shown in the drawings attached to the patent of 1862, and we believe it is subordinate to the patent of 1862.

X-Q. 59. Is the post as described in your patent of 1865 a better post

for practical purposes than the particular one or form described in the patent of 1862?

115 A. That depends altogether on circumstances. Were I constructing a bridge under the same conditions as applied to the arsenal bridge, I should use the particular form that I was induced to adopt on that bridge. Were I constructing a bridge with a wrought-iron upper chord which admitted of widening without increasing the cost, I might, for convenience, prefer the form particularly described in drawings attached to patent of 1865.

X-Q. 60. Point out the language in your patent of 1862 that would have enabled a person of ordinary skill to construct a post as described in your patent of 1865.

A. I would refer, conjointly, to drawings, specifications and claim of the post—the second claim—which give the idea and convey the necessary information for forming a hollow post formed of more than one piece of rolled shapes of iron united together by rivets or equivalents.

X-Q. 61. Please to indicate, by quotation, the words to which you refer, or on which you rely, as giving this information.

A. I refer you, first, on page 3, printed copy, sentence beginning: "Second, in a novel construction of a post of wrought and cast iron;" on page 4, from the words "the principal portions A A," to the words "by shocks," on page 5; also, "to claim 2d," on page 6, from the words "the post," to the word "equivalents;" also to the drawings of the post.

X-Q. 62. When did you first adopt in practice a post of the peculiar form described in your patent of 1865?

A. I believe in 1866, in the Dauphin bridge.

X-Q. 63. Did you ever construct a post as described in the patent of 1862, except in the arsenal bridge?

A. I did not; and, as I was engineer for the Pennsylvania Railroad for several years after the construction of that bridge, and could not induce them to use wrought-iron posts during that time, I had no occasion to make inquiries for wrought-iron posts, or use them.

X-Q. 64. Did you use cast-iron posts after 1862 and before 1865?

116 A. I used cast-iron posts in all the truss-bridges constructed for the Pennsylvania Railroad Company, until the construction of the connecting-railway bridge in 1866. They considered cast-iron posts more economical, because they made their own castings principally from scrap, mixed with charcoal iron; and I could not employ wrought-iron posts as cheaply as I could obtain the cast-iron posts, at the rates at which they charged them out to the works; they charged them at net cost.

X-Q. 65. Who drew the sections of the post in 1861 which had flanges?

A. I drew some, and Mr. Piper drew some, that had flanges. Mr. Crueger made the "working drawing" of the fore-part post with flanges, which I first had drawn for the Schuylkill bridge. He made this drawing from my sketches and explanations, and under my direction, in my office.

X-Q. 66. When was this?

A. In reference to the first sketches made by myself and Mr. Piper, it was, as I have already stated, early in and during the summer and in the fall of 1860; and in reference to the working drawing made by Mr. Crueger, it was after the 15th day of December, 1860, or early in the winter of 1861.

X-Q. 67. When was the working drawing made by which the work was constructed?

A. I have stated previously that it was after December 15th, 1860, and I believe prior to April 1st, 1861.

X-Q. 68. Then, I understand, you had a "working drawing" made before the adoption of a plan upon which the bridge was to be constructed?

A. The drawings made before were not the drawings to which I have referred as "working drawings;" the working drawings for this bridge indicated the exact size and dimensions of all the parts; the drawings made previous to this did not give the exact sizes and dimensions of the parts, but exhibited the method of constructing the post with sufficient accuracy to enable a skilled mechanic to understand the construction of a hollow post.

X-Q. 69. And those first "working drawings" delineated a post
117 of wrought iron composed of more than two pieces, with flanges, did they?

A. My answer is, that the drawings made before were not the drawings to which I have referred as "working drawings."

X-Q. 70. Was there ever a "working drawing" made of a post for that bridge composed of more than two pieces, and the pieces having flanges?

A. There was a drawing made to a scale.

X-Q. 71. Describe the shape of these four pieces which were to constitute the post.

A. The pieces were four quarter circular discs, with flanges on the edges of each, united together by rivets through the flanges and interposed ferrules, as shown in Linville 1, Figure 2; the bars composing the posts being spread apart, as shown in the figure, to admit the counter rod to pass through the post without cutting the material.

X-Q. 72. Was this drawing made before or after you consulted Charles E. Smith?

A. I believe it was some time before I consulted him.

X-Q. 73. Was it before or after you objected to the use of flanges in the post to be used on that bridge?

A. As already stated, it was previous to that time.

X-Q. 74. Is that drawing in existence?

A. Previous to the battle of Gettysburg a raid was threatened at Altoona, and all our drawings were hurriedly packed and shipped, with the cars, engines, and tools at Altoona, towards Snow Shoe. At that time many of my sketches and drawings which were not considered of immediate use or value were lost or destroyed. About the time I left the Pennsylvania Railroad service at Altoona, the engineering drawings left there by me were transferred to the new office, and afterwards re-arranged and assorted, and I have not been able to find any of the sketches or drawings referred to, except the "working drawings" by which the bridge was actually constructed, and the drawings which I retained in my own possession, and the most of which have been exhibited in this case. I have not been able to find the "working drawing"
of the circular post of four pieces with flanges, referred to.
118 X-Q. 75. Did Mr. Piper see this drawing?

A. Mr. Piper was frequently in my office while the drawing was being prepared, and I believe he saw it.

X-Q. 76. Who prepared your specifications of the patent of 1862?

A. Munn & Co., of New York.

X-Q. 77. Who prepared the drawings to be annexed to the specifications?

A. It was made by Edward E. Crueger directly from the "working drawings" of the Schuylkill bridge.

X-Q. 78. Was this under your direction or supervision?

A. I directed Mr. Crueger to prepare the drawings, following generally the "working drawings" of the Schuylkill arsenal bridge, reducing the size. I was very much occupied at that time, frequently absent from Altoona. I forwarded the drawings and models to Munn & Co.

X-Q. 79. You made oath to the application?

A. Yes, sir, I did.

X-Q. 80. Explain now why no distinct reference is made in the text, and none whatever in the drawings, in reference to the sections less than semi-polygonals.

A. Munn & Co. drew the papers and forwarded them to us for our signature. Mr. Piper and myself both read the claim, and we believed that the word "equivalents" in the second claim referred to the number of pieces as well as the mode of combining them, and we had the impression at the time that it covered the novel idea of making a hollow post of any number of pieces, and that it would be sufficient to protect us against any subsequent claimant, without describing in detail, either by drawing or otherwise, every imaginable form or number of pieces that could be suggested to form a hollow post.

X-Q. 81. Did you furnish Munn & Co. with any drawing, such as shown in Figures 1, 2, 3, 6, 8, or 9?

A. I did not.

119 X-Q. 82. Explain why it was that there was no distinct reference in the text, and none whatever in the drawings, to the use of flange-pieces, or the modes of fastening through the flanges.

A. For the same reason that I have just stated.

X-Q. 83. Look at the post, plate 440, Figures F, G, H, and K, in the September number of the "Allgemeine Bauzeitung." Are not those properly described as stiffened cruciform columns?

A. I think not. I think they would be more correctly described as hollow square columns, with ribs interposed between the flanges and meeting at the centre of the column, or, according to the description, one bar passing entirely through, the other two meeting at the centre. This definition will accord more nearly to the description in the text.

X-Q. 84. Is not the cruciform part of that column the principal part, as respects material used?

A. In Figure G it does not appear that the greatest amount of material is in the bars passing between the flanges and meeting at the centre; and if it were I would not consider this sufficient of itself to designate the post as a cruciform post, since the object sought to be obtained, as shown in the translation, was to "produce in the centre of the combination hollow spaces," &c., by reason of which the rigidity of the column is increased.

X-Q. 85. Is not the cruciform portion of a column called in the text the central body of the column?

A. It is called the "centre body" of the column.

X-Q. 86. The hollow spaces are caused by the connecting pieces, are they not?

A. The connecting pieces without the flat bars would form a square hollow post; flat bars merely cut the hollow space into four parts. The portion of iron in the peculiar-shaped irons with flanges acts with much more beneficial effect than the iron in the flat bars.

X-Q. 87. What is there in that description to indicate the use of the "peculiarly-shaped irons with flanges thus connected," as a post, without

the use of the plates which form "the centre body of the column?"

120 A. The description describes the two portions of a column in detail; it does not describe either a cruciform column without the peculiarly-shaped irons, or a square column without the cruciform body.

X-Q. 88. Does not that column throw the bulk, or a considerable part of the bulk, of the material into the centre?

A. That would be determined entirely by the option of the party constructing the column. The principle of the column as described would, in my opinion, be the same, without reference to the thickness or bulk of the separate parts, or even if the plates were omitted entirely, since the object appears to be to increase the rigidity of the column by disposing a portion of the material away from the centre toward the periphery, thus forming hollow spaces.

X-Q. 89. Supposing a man, in constructing a column, to follow these drawings as they are, would not a considerable part of the material of the column be placed in or near the centre?

A. Not necessarily. The flat bars passing through the square columns appear to be intended for convenience in the connection of the framing of this building. If making a column for any special purpose, from the suggestions contained in these drawings and descriptions, he would most probably be struck by the novel feature there described, of spreading the material away from the centre in order to increase its rigidity; and I therefore think that, with these drawings, and suggestions contained in the description, he would omit the flat bars entirely.

X-Q. 90. Is not one of the peculiarities of Mr. Reeves' post, as described in his patent of 1862, and your post, as described in your patent of 1865, that they have no material in the centre, but the whole of the material in them is as near the circumference as is possible?

A. It is.

X-Q. 91. Is there not a distinction in this respect between those posts and the posts described in the book above referred to?

A. There is that distinction in reference to our patent; but with regard to Mr. Reeves' patent there is a description on page

121 3: "Plain bars of iron, *a a a*, between the flanges of the bars, and riveted through them, and extending outwards from the centre." * * * In respect, therefore, to Mr. Reeves' patent, I do not think the distinction exists.

X-Q. 92. What forms would come under the definition of wide and thin eye-bars?

A. I suppose any bar which was wider in one direction than the other, and has a wide eye, would be called a wide and thin eye-bar.

X-Q. 93. You have spoken of eye-bars used in the bridge built by Kellogg & Clark; were those eye-bars wide and thin and set on edge?

A. They had wide, thin eyes, and were intended to sit on edge.

X-Q. 94. Was not the whole body of those eye-bars, except the eye, round?

A. It was.

X-Q. 95. Do you call a round bar, with a flattened end enlarged for an eye, a wide and thin eye-bar?

A. I would call the eye wide and thin; before the eye was formed I would call the bar a round bar.

X-Q. 96. After the eye is formed is such a bar properly described as a wide and thin eye-bar?

A. I think it would be if it had a wide eye in comparison with its thickness.

X-Q. 97. Then I understand that the term "wide, thin eyebars" in-

cludes any form of bar that has a wide, thin end to it, with a pin-hole through such flattened end?

A. I think that would be a correct description of a wide, thin eye-bar, notwithstanding the fact that in our patent of 1862 we describe bars made wide in the body, for the special purpose of bearing transverse strains. For the purpose of applying the same between the ribs on the bases of the post, a round or a rectangular bar could be used with equal facility, provided the eye-end was wide and thin.

X-Q. 97½. Do you not know that Mr. Murphy used eye-bars,
122 which were wide, thin eye-bars, set on edge, according to your definition of that term, prior to the date of your patent?

A. John W. Murphy, prior to the date of our patent, generally employed "loops" for lower chords of bridges, and these loops were placed outside of the base of the post, as shown in drawings of bridges erected for him by Piper & Shiffler. In a bridge erected at Middletown from his drawings, the eyes on the square bars were made by turning the end around and welding it, and the chord-bars so formed were not disposed between ribs on the bases of the post, but, on the contrary, were all disposed outside of the base of the post, on the ends of the connecting-pin, similar to the plan proposed at the Newark dyke bridge, before referred to. I am not aware that he ever employed wide, thin eye-bars interposed between ribs on the basis of the post.

X-Q. 98. What is the difference and purpose between wide and thin eye-bars set on edge, and used as tension-braces in bridges, and the same bars used in lower chords?

A. In one respect the functions performed are the same. In both cases they resist tensile strains. When used as chords, as claimed in our patent of 1862, the additional purpose is to bring the bars as closely together as possible on the pin, and to be able to arrange them between the ribs of the post, and at either side of the suspension braces in order to prevent the bending of the connecting-pin. The thinner the bars are made the shorter the pin becomes, and the narrower the base of the post, making the connection more secure, compact, and economical.

X-Q. 99. Point out in your patent of 1865 any words which describe the mode of making these wide, thin eye-bars by the upsetting process.

A. On page 4, printed copy, commencing—"3d. The use of bottom chords," to the words "between the eyes;" also, on page 7, commencing at second paragraph from bottom of page 7, at the words "the lower chords D," to the words "chord-bar;" also, the last paragraph of page 7, from the words "but merely the use of chord-bars for bridges, the eyes of which are thus formed," &c.; also the third claim of said patent.

123 X-Q. 100. Then I understand that you do not claim a patent for the machine or process by which this upsetting is performed, but the use of the eye-bars when so made for forming lower chords of truss-frames?

A. I do not understand the patents as covering the machine. I understand it as covering a new article of manufacture—that is, lower chords made by being upset in moulds under immense pressure, thereby increasing the toughness, density, and strength, &c.—and securing the exclusive right to use the same.

X-Q. 101. This process is performed by machinery of a peculiar kind, is it not?

A. The moulds in which the chords are formed, and the follower through which the pressure is applied to the end of the chord, is peculiar to all the machines that I have knowledge of. These are essential portions of

the machines; the method of confining the mould, and of producing the requisite power to compress the heated iron, varies in all the machines that have been constructed since the invention of our Altoona machine, and may be varied at the will of the manufacturer.

X-Q. 102. Is there anything in your patent which will enable a mechanic to form or make the eye-bars as described by you?

A. I believe there is in the references already given. We describe these bars as made by "upsetting the bars by compressing into moulds into which heated iron is forced under immense pressure." This indicates the shape of the bar—the moulding of it—the means by which the moulding was produced, and indicates, in my opinion, the essential portions of the machine, and the process of moulding bars under pressure.

X-Q. 103. Were these machines, moulds, &c., by which this work is done, well known to the trade at the date of your patent?

A. Our machines were in use at the date of our patent, also Mr. Reeves'.

X-Q. 104. Do you know of any others?

A. Kloman's machine, at the Union Mills.

X-Q. 105. When was this built and put in operation?

A. I think early in 1864.

124 X-Q. 106. Who invented that?

A. I believe Piper and myself invented all that was new in that machine. It was made at our suggestion.

X-Q. 107. When did you invent your machine?

A. In 1861 and 1862.

X-Q. 108. Was that, or any other machine for this purpose, ever patented?

A. I think Kloman's was in 1866, by Andrew Kloman. Sellers also got a patent for his machine.

X-Q. 109. Did you or Piper ever apply for a patent for such a machine?

A. We did not.

J. H. LINVILLE,

Sworn and subscribed before me this 6th day of April, A. D. 1870.

JOHN RODGERS,
Examiner.

125 Circuit court of the United States, eastern district of Pennsylvania.

THE KEYSTONE BRIDGE COMPANY *vs.* THE PHŒNIX IRON COMPANY ET AL. } In equity. No. 45.

SAMUEL J. REEVES *vs.* THE KEYSTONE BRIDGE COMPANY ET AL. } In equity. No.

SAMUEL J. REEVES *vs.* JACOB H. LINVILLE ET AL. } In equity. No. 4.

It is hereby agreed that printed copies of the testimony that has been and that may be taken in behalf of the parties, respectively, in the cause first above entitled, shall be by the examiner filed in each of the

other causes above entitled; and that the same, when so filed, shall have the same effect at the hearing of said causes respectively as if regularly taken therein.

It is further agreed that the testimony shall be closed on or before January 15th next, and that said causes shall be brought to a hearing as soon as practicable thereafter.

CHARLES B. COLLIER,
Of Counsel for Keystone Bridge Company.
R. C. McMURTRIE,
For S. J. Reeves.

PHILADELPHIA, August 9th, 1870.

126 It is also agreed, that assignments of the patents referred to in the first above-entitled suit were executed by Linville & Piper to said Keystone Bridge Company on the 1st day of May, A. D. 1865, by instrument duly recorded in the U. S. Patent-Office, and formal proof of such fact is hereby waived.

It is also understood that the several patents sued on herein, and in the suits of Samuel J. Reeves against the Keystone Company and others, are in evidence.

CHARLES B. COLLIER,
For Keystone Bridge Company.
R. C. McMURTRIE,
For S. J. Reeves.

127 Circuit court of the United States, eastern district of Pennsylvania.

SAMUEL J. REEVES *vs.* JACOB H. LINVILLE AND JOHN L. PIPER, AND the Keystone Bridge Company.	April sessions, 1868. No. 4.

Depositions of witnesses produced, sworn or affirmed, and examined on the part of the complainant, before the examiner appointed in the above cause.

DECEMBER 23D, 1869.

Present: Charles B. Collier, esq., attending as counsel for the defendants, and R. C. McMurtrie, esq., for complainant.

SAMUEL J. REEVES, a witness produced on part of the complainant, being duly sworn, saith:

I am the party plaintiff in the above suit, and am vice-president of the Phœnix Iron Company.

Question 1. How long have you been a manufacturer of various forms of malleable iron and rolled iron?

A. Since 1844.

Question 2. Are you intimately acquainted with the art and with the history and condition of the art at different times since 1844?

A. I think so.

128 Q. 3. Is such knowledge necessary to you in the business that you have been conducting since 1844?

A. Yes.

Q. 4. State what were the forms in which malleable iron were used to serve as posts for bridges and other structures prior to January, 1862.

A. The forms previous to 1862 were according to the following-described figures, viz, 1, 2, 3, 4, 5, 6, 7, &c.

Figure 1 consists of two bars ⊣ placed back to back and riveted together through their flanges, or set apart with intervening ferrules or washers, through which bolts passed, fastening the flanges of the ⊣ bars together. The setting of these pieces apart permitted the diagonal tension-braces of trussed bridges to pass between the two ⊣ bars. Sometimes these bars were sprung apart in the middle for the same purpose, being held together in the same manner. This was a very common device in bridge construction.

Figure 2. The same ⊣ bars reversed, with the ribs towards each other, - - braced between them with lateral bars and diagonal bars, all riveted to the ribs of the ⊣ bars.

Figure 3 are two channel-bars, placed back to back, with similar provision for fastening them together as in Figures 1 and 2.

Figure 4 are the same bars reversed and bolted together with filling pieces or separators.

Figure 5 is a pair of angle-bars held together in the same manner as in Figure 1.

Figure 6 ⌐⌐ is an arrangement of four angle-bars, arranged so as to be similar in effect to No. 1.

Figure 7 is a pair of H-bars, arranged in the same way.

There are other forms that were used that I do not think of just now.

Q. Are you familiar with the patents and specifications of those patents granted to J. H. Linville in January, 1862, and to yourself (S. J. Reeves) in June, 1862?

A. I am.

129 Q. 6. Point out, in detail, the distinctions or differences between those patents, or rather the subject-matter of those patents, particularly with reference to the form of the posts described in those patents, respectively.

A. Mr. Linville's post consists of two pieces of T-bars, set back to back, as in Figure 1, and of two pieces of angle-bars, set back to back, as in Figure 5; two semicircular pieces, as in Figure 8, set with the concave parts towards each other, and of two semipolygonal pieces as in Figure 9; all of which are secured together respectively by means of distance-pieces, washers or ferrules, and rivets, or bolts or bands. These pieces are set in such manner, with respect to each other, as that their tops and bottoms are drawn together, and they are set out at the middle. Caps and bases were cast around the ends of the posts. The openings are represented to be made for two purposes—one to admit the tension-braces between them without cutting away any of the iron, the other for increasing the strength of the post. The difference between my column and this consists in the use of three or more wrought-iron bars, similar to those marked *a a a* in the drawing attached to the patent, as in Figure 10, that being one of the forms. These pieces are made with flanges on their edges their whole length, and when arranged together for the purpose of composing a post or column, the flanges come face to face, and are secured by rivets or bolts. The same pieces may be set apart and secured together by rivets or bolts passing through their flanges and through a washer or ferrule of such thickness as may be desired to limit the opening. These pieces are riveted at short distances apart so as to combine the whole together as a unit. Mr. Linville's post has no flanges to the pieces composing it, unless it may be considered that the angle-irons are flange-pieces; but in that case they

are all flanges, and no body. I should have said, in referring to the forms in use previous to 1862, that the Phœnix Iron Company had made an arch, which is not exactly a post, by placing two bridge-rails flange to flange, and riveting them together at the flanges. My post, as described above, is adapted to receive caps or bases of any kind desired; those are the differences so far as the description is concerned.

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Q. 7. The points of difference, therefore, are—first, in the number of pieces of which the column is composed; secondly, in the use or absence of flanges to those pieces; thirdly, in the mode of uniting or fastening the several pieces of the column together; and, fourthly, in keeping the pieces in a straight line, and therefore parallel to each other, or forming into curves by swelling the post in the middle.

(Objected to, the witness having pointed out, in his answer to question 6, the differences between the posts, and the question No. 7 being leading and argumentative.)

A. I consider my description of it amounts to that declaration.

Q. 8. If there be any advantage in the employment of three or more pieces with which to compose the post, whether it be*ing* in reference to the facility of manufacture, or in the advantage for practical purposes after manufacture, please point out those advantages, distinguishing those which belong to the manufacture and those which belong to the use of the article.

(Objected to as leading.)

A. In manufacturing there is an advantage of using three pieces instead of two, because it is easier to roll a section which is less than a semicircle than to make in two pieces; the greater the number of segments composing the section of the post the flatter the pieces become; that is, their depth is decreased, and all the metal lies closer to the pitch-line of the rolls; they are therefore more easily made; they can be more uniformly varied in thickness; the pieces can be made cheaper; and all these advantages are greater in proportion as the number of pieces composing the post is increased. By increasing the number of pieces a post of any diameter and any reasonable length, and of varying thickness of metal, may be made in an ordinary rolling-mill as readily and as cheaply by the pound as posts of small diameters. As to the use of these pieces in composing the posts, and the use of the post itself, the making of them of numerous pieces enables the workmen to handle them with facility, and to put them together readily with ordinary appliances in the shop. The advantages of this form, consisting of more than two pieces, so far as respects the use of the post itself, consist in the fact that, as a whole, the pieces serve as buttresses or braces to resist the tendency to bend under a load. The greater the number of these buttresses or braces in the column, the more perfect is its resistance in every direction, and the flanges, which serve the purpose of attaching the pieces together, serve to increase the strength of the entire column. If they were made in two pieces, and so riveted together at the flanges, the flanges would be opposite to each other, and the column would be out of equilibrium, having one of its diameters thoroughly braced by the flanges and the diameter at right angles to the other with no such braces. There would therefore be no advantage as to the strength of such a column from the use of these flanges, and they would only serve the purpose of attachments. By increasing the number of pieces, I can adapt the post to such variable sizes as will satisfy the demands of engineers in all kinds of bridge or other structures; whereas by limitation to two pieces there is also a limitation of

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diameter or cross dimensions determined by the difficulties which come in in rolling pieces of great magnitude in the rolling-mill, and of putting them together in the shop. In the use of two pieces, that limit is attained at a very moderate diameter, and far inside of the requirements of engineers.

Q. 9. If there be any advantage in uniting pieces composing the post through the flanges, as described in your patent, over the mode as described in Mr. Linville's patent of January, 1862, point them out.

A. I have already spoken of the advantages in my own post; and in respect to Mr. Linville's, the pieces composing his post are defective in several particulars; the pieces are fastened together by bolts, which tie them in a different manner from that of riveting when the pieces
132 are brought in contact. In the case of my post, the rivets take the place of welding or of uniting the pieces into a whole. In Mr. Linville's the bolts do not accomplish this purpose; the shank of the bolt is of such a length as to constitute it a tie-rod—the distance-piece acting as the brace to that tie-rod; but there are no diagonal ties reaching from one distance-piece to the other to perfect the bracing vertically as well as laterally; consequently, a downward force exerted upon one-half of the column, while the other remained partially or wholly unstrained, would enable the piece to move notwithstanding the attachment, and the two pieces, though tied together, must be regarded as two independent posts. The post, as a whole, is weaker in the direction of its greater diameter, but the independent pieces are stronger in what would be the narrow diameter of the post, and weak in that which constitutes the depth of the pieces; therefore, it is easy to see why the entire post is weaker in its greater diameter; each independent piece obeys the law of columns, and gives way in the direction of its narrow diameter, and that direction coincides with the long diameter of the entire post. The swelling of the pieces apart, therefore, at the middle, instead of increasing the strength of the post—that being one of the advantages claimed for it—is actually a cause of weakness. In my post, the pieces being all riveted up close together, and the flanges acting as braces to the shaft, makes it uniformly strong in nearly all of its diameters.

Q. 10. State what was the occasion of, and what led to your invention of the post as described in your patent of June, 1862.

A. Somewhere about the latter part of January, or early part of February, of 1862, Wendell Bollman, an experienced bridge-builder from Maryland, in the employ of the Baltimore and Ohio Railroad Company, called on me at my office on business. I had an order from him at that time for certain channel-beams which he was intending to use in a bridge made up somewhat like Figure 4, except that plates were riveted upon the outside instead of distance-pieces between. In the course of conversation Mr. Bollman said it was a great desideratum among bridge-builders to secure or to obtain a suitable wrought-iron post for
133 bridges. I said to him, Mr. Linville has introduced a wrought-iron post in his bridge over the Schuylkill, near the arsenal. "Is not that a good post?" He said, "No, it would not answer—that a good post was yet to be made." He said, "Now, you think it over, because it is a very important matter." He impressed upon me, very emphatically, the importance of the thing, and then left the room. After he had left I put my mind upon the matter, and soon after designed and delineated the post which I subsequently patented. I had no conference with any one about it: had never discussed the matter with any one except Mr. Bollman, in the way related. I had never seen Mr. Lin-

ville's patent; did not know that he had patented a post. I did not know how that post was made. I once saw the bridge; was about ten minutes looking on at a distance, I suppose, of about two hundred feet, standing on the wharf on the east side of the river, at which time I think one of the western spans was up, or nearly up. That visit was one of general curiosity, and not of examination of any of the details of the bridge. I did not know that I had invented a patentable contrivance at the time, and its novelty was suggested to me by others. I then searched all the scientific books that I could obtain, to see whether there was anything like it in print. Finding nothing resembling it, I was satisfied that it was an entirely new device of a post. Then I applied for a patent and obtained it.

Q. 11. Referring you to the specifications in Mr. Linville's patent of 1862, state whether there is anything therein contained which would enable or direct a person skilled in the art of working malleable iron to make a post such as you have described in your patent of 1862.

A. There is nothing more suggestive about the post of Figure 8, or Figure 9, than there is in the other figures that I have alluded to as being in use before 1862.

Q. 12. Have you any knowledge of any posts having been made according to the suggestions of that patent in the particulars employed in the arsenal bridge, which is similar to Figure 9, since the building of that bridge?

134 A. No, sir; I never heard of one.

Q. 13. Do you know of any structures by Mr. Linville, or under his direction, in which iron posts were used?

A. Yes, sir.

Q. 14. What kind of iron posts were used in those bridges?

A. In the Steubenville bridge the posts are made of cast iron. In the bridge over the Schuylkill, of the connecting railroad, the column is made of four pieces of flanged iron, fastened together by rivets through their flanges, but sprung apart at the middle to admit the diagonal braces, similar to Figure 10, except that the pieces are not in parts of circles, but in parts of octagons. There is another bridge, which I have never seen, over the Delaware River near Easton—over the Lehigh also—which I have reason to believe has posts similar to the connecting bridge. I have heard of others, but I do not know where they are.

Q. 15. Referring you to the extract from a letter of the 5th January, 1863, state whether you did write such a letter to Mr. Linville.

A. I did.

(Counsel for Mr. Reeves and the Phœnix Iron Company calls upon the counsel for the Keystone Bridge Company, and Messrs. Linville & Piper, to produce the original of this letter at the hearing.)

Q. 16. Did you, after that letter was written, direct any one, and who, to forward to Mr. Linville, at Altoona, specimens of your columns?

A. I directed the superintendent of the Phœnix Works to send Mr. Linville two specimens of my columns, made after my patent, to be forwarded to Altoona, which he sent.

Q. 17. What led you to do this?

A. In the hope that Mr. Linville would use the columns, when he saw them, in the Steubenville brdge.

Q. 18. Are you familiar with Linville & Piper's patent of 1865, and specifications therein contained, in reference to the construction of columns?

A. I am.

135 Q. 19. Point out what are the variations, in respect to the column, between that patent and his patent of 1862, and in what respects those variations accord or differ from those in your column, as described in your patent of 1862.

A. If I were to go into the particulars of the difference between the two, I would recite what I have said constituted the difference between my own and that of Mr. Linville's of 1862, with one exception. Mr. Linville, in his patent of 1865, makes all his pieces open between the flanges, and springs them apart in the middle, and closes them in at the top and bottom. The particulars about the cap and base, not referred to in mine, I consider as appendages of the column. I consider that the shaft, without the base or cap, may of itself constitute a column. Some columns have capitals and no base, as in the Doric order; others have bases and pedestals, and no capitals—such for instance as are used in supporting statues, also in bridges. The joint box and the top chords in certain kinds of construction are arranged to receive the ends of the posts without any additional cap. I think, in all essential features, Mr. Linville's post, as described in his patent of 1865, is identical with mine. The swelling of posts at the centre is not a new thing, nor is it useful for any other purpose than that of passing braces between them; nor is that a new thing, being a common mode of arrangement in bridge construction for a long time. Swelling adds no strength; the column would be equally strong if the pieces were parallel from top to bottom, and perhaps stronger. Iron resists with greater power when the metal is arranged to coincide with the line of strain. Any deviation causing an angle to be made between the line of strain and the line of the metallic support, diminishes its power of resistance in proportion to the magnitude of that angle, the falling off of the powers of resistance being directly as the secants of the angle, calling half the height of the post as radius, equal to unity or one. I will give the secants of several angles as below:

The secant of 5° = 1,003,820.
" 10° = 1,015,147.
136 " 20° = 1,064,178.
" 30° = 1,154,701.
" 45° = 1,414,214.

Q. 20. What is the largest column that you have received, and taken an order to build, in the form described in your pattern?

A. The largest columns that we have yet made are about, I think, eighteen inches in diameter. We are preparing to make a tender for a column of about twenty inches diameter in the barrel, and of a thickness varying as shown in the eight-segment piece in Exhibit I.

Adjourned to meet on Friday, December 24th, 1869, at 11 o'clock a. m.

DECEMBER 24th, 1869.

Met pursuant to adjournment. Present: Mr. McMurtrie, for complainant; Mr. Collier, for defendant.

Continuation of the testimony of SAMUEL J. REEVES.

Q. 21. You mentioned at the beginning of your examination that there were certain forms of posts composed of malleable iron used prior to January, 1862. If you know of any drawings, either in printed books or otherwise, which exhibit these forms as in use prior to that time, point them out.

A. In answer to this question, I refer to Humber on Bridge-Construction, volume 1st, printed in London, 1861, pages 104 and 105 of the text,

for some of them. The figures are in the text. "The Construction of Wrought-iron Bridges. By John Herbert Latham. 1858. London." Pl. 1, Figures 1-2, show open posts made of T-bars, standing rib to rib, with diagonal bracing, and Figure 4, angle-bars, with solid plate
137 connection; also, Figure 2 shows top chords made of channel-iron and plates riveted together above and below. Figures 1 and 4 show cellular tops—the middle not quite connecting, being for same purpose as Linville's. Plate 5, Figure 21, show two channel-bars, set back to back, used as compression-braces in a lattice bridge; also, sundry drawings, made by the Phœnix Iron Company, marked Nos. 1, &c., consecutively; also, Haupt on Bridges.

Q. 21½. You have said in a former answer that the springing out in the Linville post weakened it in the direction of the larger diameter. Can you refer to any authority in corroboration of your opinion of this law of mechanics?

A. I can refer to the testimony already given by Mr. Piper in that respect, in the practical experiment in which he stated that at the trial of one of those columns it did give way in the direction of the largest diameter. I read from Experimental Researches, by Hodgkinson, Part 2, London, 1846, page 349, &c.

Strength of pillars of various forms, and diffierent modes of fixing, copied from Tredgold, vol. pp.

"In hollow pillars of greater diameter at one end than the other, or in the middle than at the ends, as in Table XI, (Art. 36,) it was not found that any additional strength was obtained over that of uniform cylindrical pillars; on the other hand, the strength of these seemed to be the greatest. With respect to this, however, the conclusions were not very decisive. The result from the comparison is in agreement with what may be deduced from Euler's theoretical values of the strength of uniform cylindrical solid pillars, and of those in the shape of a truncated cone. (Berlin Memoirs, 1757.) His formula for these being—

$$\text{"P} = \frac{a2,\text{D}4}{\text{A}2,d4}\text{p, and P}' = \frac{a2,\text{D}2,\text{E}2}{\text{A}2,\ d4}\ \text{p.}$$

"These values are to one another, *cæteris paribus*, as D^4 to D'^2, E^2; where D in the diameter of the uniform pillar, and D′ E the diameters of the two ends of that in the form of a truncated cone. But if we compute the diameter of any uniform cylindrical pillar of the
138 same length and solid content as one with unequal diameter, we shall find the uniform pillar stronger than the other, and the more so according as the inequality of the diameter of the latter is greater.

"The strength of a pillar in the form of the connecting-rod of a steam-engine was found to be very small, indeed less than half the strength that the same metal would have given if cast in the form of an uniform hollow cylinder. The ratio of the strength, according to my experiments, was 17,578 to 39,645.

"A pillar irregularly fixed, so that the pressure would be in the direction of the diagonal, is reduced to one-third of its strength, the case being nearly similar to that of a pillar with rounded ends, the strength of which has been shown to be only one-third of that of a pillar with flat ends.*

* Tredgold, Art. 283 of this work on cast iron, and in his Treatise on Carpentry, following the idea of Serlio, in his Architecture, recommends circular abutting joints, to lessen the effect of irregularity in the strain upon columns, from settlement and other causes; but this, we see, is voluntarily throwing away two-thirds of the full strength of the material to prevent what may often be avoided.

"Uniform pillars fixed at one end, and movable at the other, as in those flat at one end and rounded at the other, break at one-third of the length (nearly) from the movable end; therefore to economize the metal, they should be rendered stronger there than in other parts.

"Of rectangular pillars of timber, it was proved experimentally, that the pillar of greatest strength, where the length and quantity of material is the same, is a square."

Q. 22. What is the mechanical rule or law for ascertaining the power of resistance to compression?

A. The (2).

"*Rule for calculating the resistance of long struts and pillars to crushing by cross-breaking.*

"FORMULA.—$P = \frac{f s}{1 + a \left(\frac{1}{h}\right)^2}$,

in which P = crushing load of a long pillar in pounds;
" S = sectional area of material in square inches in it;
139 in which l = its length;
" h = its least external diameter;
" f = modulus, depending on the nature of the material, and is nearly equal to the modulus of the resistance of *short blocks* to crushing;
" a = a multiplier in the divisor, depending—first, on the nature of the material; second, on the mode of fixing the piece; and, third, its form of cross-section, being greater in proportion, as its cross-section is more flexible.

"The value of f, for cast iron, is..... 80,000 pounds.
" " for wrought iron, is..... 36,000 "
" " for timber, (average,)..... 5,500 "

"The value of (a) for struts and posts, *fixed firmly at both ends*, the section of which is a hollow cylinder, is:
$\frac{1}{400}$ in cast iron;
$\frac{1}{3000}$ in wrought iron;
$\frac{1}{4500}$ in wrought iron, very thin tubes.
" " in cruciform-pots, $\frac{1}{1500}$
" " in rectangular form, $\frac{1}{250}$ in timber."

The above formula, expressed in words, is as follows:

Divide the length of the piece by its least outside diameter; square the quotient, and multiply the square by a suitable constant multiplier; to the product add unity; divide the proper constant modulus by the sum; the quotient will be the resistance to crushing per unit of sectional area, *depending on the form of the section and on the nature of the material.*

NOTE.—For struts or pillars, *jointed at both ends*, multiply the value of (a) by 4; for ditto, *fixed at one end* and jointed by the other, by 2; for factors of safety, use 6 for cast iron, 4 for wrought iron, and 10 for timber. In my calculation for the strength of my column, both ends being firmly fixed, I take the value of (a) in the divisor as equal to $\frac{1}{3000}$, and h as the diameter in the barrel or circular part. I believe experiments will prove that I might properly use a value of (a) $= \frac{1}{4500}$, and h
140 as the distance from the exterior of one flange to the exterior of the next, if the post is composed of four pieces; and

from out to out, of nearly opposite flanges, when composed of many segments. Several eminent engineers do adopt these values for (a) and (h) in their calculations for the strength of my post. C. Shaler Smith, C. E., also uses a value for f=to 40,000, instead of 36,000 for wrought iron.

Q. 23. Suppose a column of certain length, and one foot in diameter, and a similar column in all respects, except that the diameter was increased, say one inch, and so on, inch by inch, what was the relative power of resistance longitudinally; does it increase as the diameter is increased, and in what ratio?

A. It increases where the same sectional area, which is, in other words, an expansion of the metal; the strength increases in the ratio of the squares of the respective diameters into the square of the length of the column. The expression is, $(\frac{1}{d})^2$.

I will give the following particular examples: Suppose the length equals twenty times the diameter, then the square of the length is 400. Again, suppose the length is thirty times the diameter, then the square of the length is 900. Third, suppose the length is forty diameters, the square of the length, then, is 1600. Take the first example, add 400 to 3000, making 3400; then say as 3400 : 3000 : : 3600, the value of f, as wrought iron, to P; which expresses the weight which a column of that proportion will carry for each square inch of its sectional area. For the other examples, the proportions would be—

3,900 : 3,000 : : 36,000 to P, and
46,000 : 3,000 : : 36,000 to P.

In the first example, P is equal to 31,765 pounds; in the second, 27,692; in the third, 25,480 pounds.

The above illustrations apply to columns similar in shape and condition.

Q. 24. Prior to the making of your posts, were you aware of the use of more than two pieces to form a post, except in the use of rods combined, T, I, L, and [ ] bars?

A. No, sir.

141 Q. 25. Could those be combined so as to form a post which was at the same time hollow and solid, in the sense of unity?

A. I know of no case in which it could be done, excepting in the form of box-girders, which consists of taking two pieces of channel-bars, or I-bars, set opposite to each other, and riveting to their flanges plates of iron.

Q. 26. If the pieces I have mentioned are so united as to form a solid column, in the sense of unity, in what way are they affected as to the power of resistance?

A. Suppose we take Figure 6, as shown in my answer to question . Figure 6 is in every sense a cruciform bar, except it has four pieces instead of one. It is not a hollow cylinder in any respect, because the angles come together at points; and if they be taken at any distance from a common centre inside of the four points, the circumference of that circle would be merely touched at four points, and there would be no line of metal along the periphery of such a circle; consequently this cannot be called a hollow post. As a cruciform post it does not possess one-half the strength of a cylindrical-formed post, because the mass of the iron approaches the centre of the four points; whereas in a circle it is carried as far as practicable from a given centre.

Q. 27. When, therefore, the mass of the iron is removed from the centre towards the circumference by separating four angle-irons, what is

the effect upon the whole, as a combined thing, for the purpose of resistance, and as a combined thing, in the sense of unity?

A. Just in proportion as the pieces are set away from the centre, the post departs from a condition of unity. They (the parts) become, if merely tied together and braced laterally, four independent posts, each obeying the laws of columns according to the form of its cross-section.

Q. 28. In what respects, as to power of compressive resistance, do columns constructed on your patent, where the flanges are brought in actual contact and riveted, differ from a column of the same dimensions when rolled in one cylinder?

142 A. It bears the same resemblance to a perfect cylinder, in respect to its combination as a unit, as a boiler-flue would bear to a perfect cylinder. The flanges, however, in the one would make it dissimilar, in its cross-sectional shape, to that of a boiler-flue. In effectiveness, so far as the riveting up and fastening the pieces together is concerned, it is the same as a true and uniform hollow cylinder, which latter, (*i. e.*, a cylinder,) as I understand it, is the perfect unit of comparison.

Q. 28½. What is the practical limit of diameter of an iron cylinder capable of being rolled in the best appointed rolling-mills of this country?

A. The largest in the country, I believe, are produced by Morris, Tasker & Morris. I have never seen any over six inches in diameter; but I think they have undertaken to make them as large as eight inches; but such cylinders must be very costly.

Q. 29. What is the largest size in diameter in which semicylindrical or semioctagonal pieces could be rolled in the best appointed rolling-mills in the country, with their present equipment?

A. I think the limit would be attained with the appliances of any mill that I am acquainted with, at inside of twelve inches; but the expense in attaining that limit would be considerably greater than it would be in posts of eight inches diameter.

Q. 30. What additional expense would be necessary to provide the best rolling-mill in the United States with an equipment of additional power, rolls, and train necessary to make semicylindrical pieces to compose a column of twenty inches in diameter?

A. It would involve the construction of a mill expressly for that purpose, requiring very much greater power in the engine; greater proportions in the housings and rollers; larger heating-furnaces; more men to handle the pieces in drawing the same from the furnaces, and in rolling them to shape; involving so great a cost as to call it an impracticable process, regarding impracticability as determined by the marketable value of the article produced. I should think it would cost one hundred thousand dollars to put up such a mill, and I do not know for what other purpose it would be applicable.

143 Q. 31. What appliances, other than those possessed by rolling-mills capable of rolling the heaviest forms of iron beams or girders that have been used for some time past, would be necessary to enable them to roll such a column, if rolled in pieces not greater than an eighth, or say a sixteenth, of a circle?

A. It could be easily rolled in any mill capable of making an ordinary nine-inch channel-bar, with suitable rollers for making the shape, and those would cost less than two thousand dollars.

Q. 32. How long is it since I-beams have been used as top chords of bridges?

A. Long before 1860, they have been used in pairs, separated so as to

let the diagonal vertical tension-braces go between them; they have been used side by side, and as in the form of a box-girder, by having plates riveted to their flanges on the top and bottom; they have also been used in groups of three or more, side by side, and fastened together, sometimes in combination with channel-bars—depending upon the purpose to which they are applied.

Q. 33. Can you point to any book exhibiting this use prior to 1862?

A. To Humber, (same edition as before referred to,) Plate A, opposite page 84, Figure 4.

Q. 34. Referring you to the allegations in the pleading and testimony given by Mr. Piper in reference to the tests applied to these columns of Mr. Linville and your own, have you anything to say in reference to those tests?

A. I think the table indicates a great want of care in the trial of the Reeves column, since it has only sustained, according to the table, a load of 78½ tons; with a decrease in length of column of one-eighth, and with a half a ton more added, that decrease was doubled; then by 51 tons more, the corresponding deflection was one-eighth of an inch more; then 97 tons more load only diminished it another eighth. The whole load, subjecting it to a strain of $24\frac{7}{10}$ tons per square inch of section, is represented to have deflected it one inch, and and the post to have been permanently injured. The want of uniformity in the decrease of
144 length under the respective loads indicates a want of care in the experiment, while the greatest load being $24\frac{7}{10}$ tons to the square inch, is a greater strain than any wrought iron is capable of resisting, even in the shape of a cubical block.

The iron in the shape of my column not longer than ten feet three inches and of the diameter of eight inches, which were the dimensions of the post submitted for trial, should have resisted an ultimate strain of ten tons without set, and should have sustained about fifteen tons to the square inch, without being crippled. The fact of its sustaining so small a load, is evidence that it was not fixed fairly in position in the trial—that the line of strain could not have been coincident with the centre of the column, but angular to it to such an extent as would diminish its strength in the same manner as posts round at each end; it being well known that columns in such condition cannot carry a load greater than one-half to one-third of the load that they would be capable of if square at the ends and the power applied in such manner as to be parallel in its force with the line of the centre of the column. In the mechanical laws applied to posts, those having square ends turned perfectly true, and, with a power properly applied, will carry a weight of from twelve to fifteen tons per square inch without crippling; those which are round at the ends, somewhat like the end of an egg, will only carry one-third of the load first named; if one end is round and the other square, the load sustained will be a mean between the two. It is therefore of the highest importance in making trials of the kind that great care should be taken to ascertain in what condition of strain the column is subjected; unless this be done, comparative trials must be regarded as absolutely worthless. I also consider that the trial made of the Linville column is equally unreliable. I particularly note in the table (Exhibit A in table of answer) that the column deflected one-eighth of an inch under a load of 130 tons, while at several additional loads, amounting in the aggregate to 201½ tons, or 90½ tons more, there was no additional increase of deflection, which I consider entirely erro-
neous—it being impossible that the addition of 90½ tons should
145 not have been attended with an increase of deflection. I also

find on page 10, opposite to the table, the Linville & Piper column of nearly twice the length was not deflected under a pressure of $24\frac{7}{10}$ tons per square inch, and after removal of pressure no shortening of the length could be detected. I consider that an impossible condition; for iron, in its best possible shape to resist a strain, will crush under a load not exceeding fifteen or sixteen tons. I have proofs of that fact in sundry works of acknowledged authority, and would refer particularly to the "Report of the Commissioners appointed to inquire into the application of iron to railway structures," &c., published in 1849, in London, pages 117, 120, 121, 122, 123; table 6, page 147, &c.; page 163; also, to same book before referred to, "Experimental Researches," by Hodgkinson, Part II, table 4, page 370; also, to Clarke's work, "Britannia and Conway Tubular Bridges," London, 1850, Vol. I, Chapter II, contents and tables—especially table 10, page 343, and pages 344, 345. I conclude from these facts that the trials must have been carelessly managed, or that their machine was not in a condition to indicate with certainty the true results. The table indicates that it was the Reeves column which was subjected to a test of $24\frac{7}{10}$ tons per square inch, and not that of Linville & Piper's; there is therefore a disagreement between the statement on page 10 and the table itself.

Q. 35. Were eye-bars used in bridge-building prior to 1862? And if so, point to any evidences of that fact within your knowledge.

A. Yes. I have a description and details of a bridge in which eye-bars were used as bottom chords of a bridge, which I take from a book called "Papers and Practical Illustrations of Public Works of Recent Construction," &c., published in 1856, page 89, &c., entitled a descrip- of "Newark dyke bridge," on the Great Northern Railway, and in particular plate 5. I also have reference to such eye-bars being used in Hungary, at Pesth, over the Danube; also at Kief in Russia. See Dempsey on iron-girder bridges, published in 1850, page 131; see Clarke, vol. 2, pages 509–10; see Humber, vol. 1, page 129.

146 Q. 36. What has been your experience in manufacturing these eye-bars upon the machine described in the patent issued to Mr. Sellers, and what has been found necessary to form a complete flat eye-bar, when that machine is used?

A. The machine was found to be insufficient to fill the mould or die at one operation. The difficulty which first manifested itself was the tendency of the iron to thicken at the nearest point of pressure. The force exerted by the plunger upon the end of the heated bar did not act at the end nearest the shank of the bar with sufficient force to compel it to occupy the vacant space in the die. The tendency of the force was to expend itself in pushing out the iron which was nearest to it, because the yield must be in the direction of the least line of resistance. That least line is the thickness of the bar. The greatest line of resistance is that which coincides with the length of the bar itself. We therefore abandoned that mode of making eye-bars, and now practice a different one, which is as follows: We first heat the end to be upset, and put it into a die larger than the end of the bar, and permit the bar to thicken up as much as possible. We then take the bar to another furnace and reheat the end, and put it under a press in which there is a die of the form of the eye to be made, and flatten the end until it fills the die.

Q. 37. Is there anything, and, if so, what, in Linville & Piper's specifications to their patent of April, 1865, by which a person skilled in the business can learn how to form eye-bars by upsetting?

A. I could discover nothing.

Cross-examination by C. B. Collier, esq:

X-Q. 38. Calling your attention to the different forms in which malleable iron was used to serve as posts for bridges prior to 1862, as testified to and described in your answer to question 4, and referring to the drawing, Figures 1 to 7 in said answer, will you state what is the distinguishing feature between your post, as patented in 1862, and those described in your said answer to question 4?

147 A. The distinguishing feature is, that in the several figures referred to none of the pieces are so arranged in the composition of any one post that they can be united into a unit by riveting their flanges together, so as to constitute a hollow post or shaft, while in my post this is the distinguishing feature.

X-Q. 39. State specifically what you mean by the word unit, as employed in your last answer.

A. I mean such a combination as will resemble, in the fixture of its parts, the nearest approach to a true hollow cylinder without mobility of parts.

X-Q. 40. State the earliest date known to you personally, or from research, of the employment of posts for bridges, or for other structures, of each of the different forms, Nos. 1 to 7 inclusive, described in your answer to question 4 in chief.

A. Figures 1, 2, 5, and 6 I have found alluded to in books published in 1850. Figures 3, 4, and 7 are such as the Phœnix Iron Company had been accustomed to use for making into girders. Those were generally used in a horizontal position, and for resisting transverse strains. I should have made a distinction when I referred to these in answer to question 4; but, as the post of Mr. Linville, in his patent of 1862, referred to the use of his particular post in top chords of bridges, I had in mind the same application of them. Those have been common forms as girders in composition at the Phœnix Iron Works for a number of years previous to 1862. I have also drawings at hand of some of the designs employed at the Phœnix Iron Works, as in Figure 1, and also the same in which the pieces are parallel and sprung apart at the center.

X-Q. 41. State whether either of the figures, 1 to 7 inclusive, referred to and described by you, constitutes a wrought-iron hollow post.

A. I don't consider that they do, any of them.

X-Q. 42. State when you first knew of the construction of a wrought-iron hollow post made of longitudinal pieces of more than one piece.

A. I am not aware of any, until that of my own.

148 X-Q. 43. State whether or not the post as described in the letters-patent of Linville & Piper of January, 1862, is not a wrought-iron hollow post as described in the last question.

A. No, sir; it is no more so than Figure 4 would be, which I do not consider a hollow post nor Figure 6.

X-Q. 44. Will you state specifically in what books "published in 1850," or printed in 1861, you have found "Figures 1, 2, 5, and 6 alluded to;" and if you have the books present, will you please quote therefrom the paragraphs containing such allusions?

A. I refer to the Blue-Book of the British Parliament of 1849; Experimental Researches, by Hodgkinson, of 1842; Britannia and Tubular Bridges, by Edwin Clarke; "Public Works, British and American," published in 1852, see Figure 1, Plate 1; Construction of Wrought-iron Bridges, by Latham, (1858,) in which two T-bars, with their ribs face to face, are held together and kept apart by lateral braces and diagonals,

similar, very nearly, to Figure 2. Clarke's works, 2 vols., page 571, exhibits T-bars back to back, similar to Figure 1, except that they confine plates between them instead of diagonal ties. In volume 1 of same book, page 144, there is a diagram showing two bars in channel form, similar to Figure 3, except they have plates riveted on top and bottom as connections, instead of distance pieces. Experimental hollow columns, round and square, rectangular, which in a previous answer I have said I had no recollection of, I do find in volume 1, Clarke's work (and which I had forgotten;) diagrams and sections shown, from page 340 to 343, used by Hodgkinson in his experiments, the records of which are found in the same book. I also have a second volume accompanying the British Parliamentary Blue-Book, showing diagrams and drawings of the same experimental hollow columns recorded in Clarke's work. Figures 5 and 6 I have frequently seen, but I do not discover any of them in these books. Figures 1, 2, 5, and 6 were the general forms used as posts previous to 1860.

X-Q. 45. Calling your attention to your reference as made to Latham's work, Figure 1, Plate 1, will you state whether the T-bars shown therein were used as independent vertical posts; and, if not, for what purpose were they used?

A. They were used as posts vertically, and at the same time exterior side-plates were attached to them, running from post to post.

X-Q. 46. What kind of a bridge is described and shown in said plate?

A. A hollow girder-bridge. The top chords of that bridge are of tubular or cellular form. The bottom part is left off in that figure. I don't know what that is.

X-Q. 47. Will you point out where, in either of the works referred to by you, the posts were employed as independent vertical posts?

A. I cannot search them out at present.

X-Q. 48. Were not the different forms of iron, as shown in said works, and each of them, used as stiffening-ribs of plate, girders, lattice-bars in lattice-bridges?

A. Generally they were, but I will be able to refer to some that were not.

X-Q. 49. Do either of said references contemplate the employment of the different forms of iron therein described for the same purpose as is contemplated in the posts described in Linville & Piper's patent of January, 1862, or of your post of June, 1862?

A. They serve the same purpose in effect; but different styles of bridges have different modes of connection between the top and lower chord. Lattice bridges, with T-bars, back to back, as vertical posts, let the diagonal pieces come between them, and, where they pass the posts, are riveted to the diagonals. Where they are of a different style of bridge from lattice the diagonals may or may not be riveted to the posts; but in either case the posts serve the same purpose—that is, to keep the top or bottom apart, and that is the special duty of a post in a bridge.

X-Q. 50. Calling your attention to Figure 6, described in your answer to question 4 in chief, will you state specifically where you knew such form of post to be used prior to 1860?

A. They have been used as substitutes and as equivalents for Figure 1; and that form is older than Figure 1, because in the history of the forms of irons the angle-irons preceded in manufacture T-bars. These were sometimes applied by riveting the two pieces together to form T's, and so riveted together they serve the same duty as Figure 1. They have another special function, as shown in Figure 6,

to admit plates, or diagonal framing, in four directions instead of two. They were largely used in the construction of Brittannia and Conway bridges by Mr. Stephenson and Mr. Clarke.

X-Q. 51. In the structures specifically referred to by you in your last answer were not the pieces riveted to the side plates of the bridges?

A. They were sometimes riveted to the plates, but generally, it may be said, they were riveted together, confining the plates between them.

X-Q. 52. Can you point out the use, anterior to 1860, of such pieces as shown in your Figure 6, and separated from each other and fastened in the manner as shown in that figure?

A. No; not precisely in that manner.

X-Q. 53. Does not said figure purport to represent an independent wrought-iron post?

A. It was not intended so to be considered, but only to show the general arrangement of angle-irons, with reference to each other, used as posts in any mode of construction. Generally the two pieces are brought together so that the four should resemble Figure 1, that being a stronger and better form than Figure 6, as well as a newer device.

X-Q. 54. Calling your attention to the first paragraph of your last answer, will you state whether or not you know of the use of wrought-iron pieces for posts, arranged "with reference to each other," as shown in your Figure 6, prior to 1860?

A. No; neither prior or since.

X-Q. 55. Will you now state whether either of said Figures 1 to 6, inclusive, is intended to represent a section of an independent wrought-iron post?

151 A. Figures 1 and 2 were so intended.

X-Q. 56. Can you refer to the use of pieces of wrought iron, as shown in Figure 2, as an independent post, prior to 1860; if so, will you give such reference?

A. I have seen drawings of them, but I am unable at present to give the references in books of anterior date to 1861.

X-Q. 57. I understand, calling your attention to your Figures 4 and 6, that you cannot refer to the use (prior to 1860) of independent posts composed of two pieces or more, as shown in said figures; am I correct?

A. No; I cannot refer you to anything. Nos. 3 and 4 are used to form box-girders.

X-Q. 58. Will you now state whether you know, from research or otherwise, of the use of posts for bridges prior to 1860, composed of pieces which, when fastened together, formed a hollow wrought-iron post?

A. I have referred you to rounds, squares, and rectangles, used by Hodgkinson in his experiments, in certain works previously mentioned. These were not used for posts in bridges, but they were hollow posts, united together in the most compact and firm form then known to resist compressive forces and for the express purpose of ascertaining their adaptability to all purposes of construction in which posts were required, and particularly with reference to bridges. I know forms of the same kind used as ships' masts—that being one purpose of the post.

X-Q. 59. Can you give any other reference to the use of posts (prior to 1861) so made as referred to in X-Q. 58 other than your reference to the experiments made by Hodgkinson?

A. I cannot remember any; these pieces referred to are used as gir-

ders, as I mentioned in my corrected answer in the earlier part of the sitting.

X-Q. 60. What are the general dimensions of the experimental posts of Hodgkinson; how were the pieces formed, and how united together?

A. They vary from moderate diameters of four or ten inches; in thickness from a tenth to a quarter of an inch, and of lengths
152 varying from five to eighty diameters; they were from ten to fifteen feet long. The pieces were plates of iron riveted together in rounds, squares, and rectangles, also elliptical forms; he made also experiments on cruciform sections, T-bars, and channel-bars; these latter were in single pieces.

X-Q. 61. The pieces, then, composing the hollow columns as experimented with by Hodgkinson, were made of sheet iron, with their edges bent over, forming flanges through which the rivets passed, were they not?

A. No, sir; they were lapped over and riveted together and made up in the same manner as boilers; one of them is shown, as in trial, opposite page 85, vol. 1, Clarke.

X-Q. 62. Wherein, if at all, do columns as experimented with by Hodgkinson differ from those described in your patent of 1862?

A. Those that were subjected to trial were made up of pieces of plate-iron or sheet-iron, such as are found in the market, in pieces of marketable lengths and widths, and bent to the shape of a circle in such manner that their edges may come together or be lapped over each other so as to make the desired form, either square, round, rectangular, or elliptical; and some of them were braced upon the interior part so as to make them cellular by other pieces of iron of similar form. In some instances when they were very large, I believe experiments were referred to in which cross-plates were inserted inside the tubular pieces so as to test the resistance of the whole to a collapsing force, with a view of ascertaining the laws which such shapes should obey.

X-Q. 63. Do you mean to be understood in the first paragraph of your last answer that the difference between those posts and yours consists in the manner in which the iron for the respective posts was made?

A. Yes.

JANUARY 6*th*, 1870.

153 Re-examination continued. Present: Mr. Collier, Mr. McMurtrie.

Mr. Reeves states that since the closing of his examination at last meeting, he has made an examination in reference to certain matters referred to in the cross-examination, and that he is now able more fully to answer them.

I was asked the question where I could point out the use of T-bars, placed back to back, as independent posts. I now refer to a "Practical Treatise on Cast and Wrought Iron Bridges and Girders," &c., by William Humber, 1857, page 13, Figure 7, with the text; page 14, Figure 8, T-iron posts, with lattices between them; Plate 52, with T and angle iron post, back to back, and lattices between; Plate 37, Crumlin viaduct, Figures 1, 3, and 5; Plate 35, Figures 1, 2, 6, 7, and 8; Plate 34, Figure 13, T-iron, back to back, vertical and leaning posts; Plate 31, Figure 9, angle irons and T-irons braced as a pier; Plate 30, Figures 2 and 4, same bridge as in Plate 31. I referred to "Recueil, ch. Ferdinand Zores," printed in 1853, Plate 32, Figure 11, and a cut of same figure enlarged, showing vertical posts made of T-iron, back to back; also, description of Plate 34, showing the strut brace F in elevation; and a

cut or section at its middle, in which four angle-bars are grouped together and opened to receive flat bars, which flat bars are wider at the centre than at the top and bottom; that is, they are tapered from the centre to the ends.

Cross-examined:

X-Q. 64. State wherein posts, constructed in the manner described in the various references given by you in your above statement, resemble or differ from the post, in principle and effect produced, from the post as described in your letters-patent of June, 1862.

A. They resemble my post in that the pieces are made of wrought iron; they differ from it in that they do not admit of being made
154 into a hollow post, and are not capable of the same kind of expansion in diameter as mine; and the pieces composing the post are not made of the same form as those in mine.

X-Q. 65. Are the pieces composing the posts in either of said references, and, if so, in which one or more, disposed in reference to each other in precisely the same manner as are the pieces in the several posts, Figures 1 to 10, as shown in your illustrations given in your answer to question 4 in chief, and in the exhibit presented by you and hereto attached, marked A?

A. They are disposed similar to Figures 1, 5, and 6, excepting that some of them had nothing between them, and were riveted together only at the top and bottom, they being so short as not to require any intermediate connections. As to others, they differ in this, that the pieces, instead of being bolted with washers between them, have the intermediate pieces running their whole length and riveted together. I did not notice particularly whether any of them were united together at several points with washers alone; in other respects I think they are similar to the figures I named in Exhibit A.

X-Q. 66. I understand that you are of opinion that the post, as described in the letters-patent of Linville and Piper in January, 1862, is not a hollow, but is a solid, post; am I correct?

A. It is neither; it is an open post.

X-Q. 67. What do you understand by a hollow post?

A. A hollow post I consider to be constituted of pieces so united together as to make it, as nearly as possible, like a true cylinder, O, with no openings on the periphery.

X-Q. 68. Then, if the pieces composing the post, as described in your patent, should be swelled in the centre so as to permit the passage through the post of suspension diagonals, you would no longer consider the post to be a hollow one; is that so?

A. No, sir. I did not say that a hollow post should be like a true cylinder, without any opening in the periphery, but that the post should, as near as possible, resemble a cylinder; if the pieces were open very wide, so that the spaces should constitute a considerable portion of the periphery, such a post would not be hollow, but would be composed of pieces set apart.

155 X-Q. 69. Taking, as an illustration, a post eight inches diameter, about how far should the pieces composing such post be separated from each other in order to constitute it no longer a hollow post?

A. I do not think I can determine that by a categorical answer; (but if the pieces were united at the edges very frequently, it might still be a hollow post, even though between the attachments there were openings, and these openings might be perhaps an inch or more apart; but I would not consider two pieces of iron placed face to face as constitut-

ing a hollow post, when they were separated from each other by distance-pieces, and bolted together through one of the axes. If they were not fastened together at their edges, the pieces might open, when sufficiently strained, for want of the right kind of attachments to hold them together. In other words, I should regard two such pieces to be like two pieces of channel iron, face to face, and set apart from each other with no fastenings on their flanges, notwithstanding the edges might be brought near together or kept apart, so as to admit of interposing diagonal or tension bars between them.)

(Objected to, as not being responsive to the question, and cross-question 69 repeated.)

X-Q. 70. Cross-question 69 repeated.

A. A post which had its pieces riveted together so frequently at its edges, as would make it in nearly all respects a continuous attachment in the direction of its length, but which might have its pieces still sufficiently far apart from each other as to admit of tension-braces of any reasonable thickness, would, in my opinion, be to all intents and purposes a hollow post.

X-Q. 71. How soon after your interview with Mr. Bollman, referred to in your answer to question 10, was it that you "designed" the post subsequently patented by you?

A. I think I had all the idea on the day of the interview, as I gave my mind to it very intently, and studied out the advantages and disadvantages of it pretty thoroughly; and certainly within less than a week I had compassed the entire peculiarity of the thing.

156 X-Q. 72. Were any sketches made while Mr. Bollman was present at said interview?

A. No, sir.

X-Q. 73. What suggestions were made by Mr. Bollman to you in reference to the construction of wrought-iron posts?

A. None whatever, beyond the fact that a suitable wrought-iron post was a great desideratum with engineers. He suggested no forms nor any peculiar arrangement desirable, but only conveyed the idea to my mind that there was no such desirable post in use, and therefore he could not satisfactorily construct wrought-iron bridges for want of such a post.

X-Q. 74. Did you ask Mr. Bollman at that time whether he had seen the Linville bridge near the arsenal, or did he say that he had seen it?

A. I did not ask him, nor did he say that he had seen it, but I inferred that he had seen it, because, when I asked him if the post Mr. Linville used in that bridge was not a satisfactory one, he promptly replied that it was not.

X-Q. 75. What reason did he give for such opinion?

A. He gave none at all.

X-Q. 76. What kind or form of post did you first delineate after said interview?

A. The quadrangular form.

X-Q. 77. What kind of a delineation did you make?

A. The delineation Figure 4 in drawing attached to my patent.

Re-examination by Mr. McMurtrie:

Q. 78. If the pieces of which the post is composed are not united, saving by mere contact, have the pieces any mutual effect, and do they in any proper sense constitute a post?

A. I consider such a post as defective in its construction, because the pieces, instead of being combined in such manner as to compose a unit,

are in effect independent pieces, arranged to resemble a post, but without the quality to make it effective.

Q. 79. In such case, if the pressure on the different pieces va-
157 ries, or if the pressure is otherwise exactly vertical, do those several pieces receive any support, one from the other?

A. The resistance of each piece would depend upon its particular form in cross-sections, and of its length, and would receive no support from its neighboring pieces; and all the pieces would obey the laws due to their individual form severally, and not the laws which a post, properly composed, would obey for its entire cross-section and its entire length in terms of its full diameter.

Q. 80. If the pieces of posts are united, is not the mutual support of the several pieces determined by the strength and length of the pieces by which that union is effected?

A. Yes.

Q. 81. Is there a better test, whether a structure can be called a hollow post, or two pieces serving as a post, than this, that the length of the connections of the pieces must not be so great as to allow a motion in one part without affecting the other, thus giving each piece support from the other, in the manner which all parts of a true cylinder mutually receive?

A. Just in proportion as the character of the attachments permit' independent action in the pieces, so is the post, as a whole, defective in strength, and departs from its condition of unity.

Q. 82. Referring you to certain drawings, state when they were made and what they represent, so far as they relate to the subject of this controversy.

A. These are the drawings referred to in my answer to question 21 in chief. The examiner has identified them by his initials J. R. and the numbers 1, 2, 3, &c., January 6th, 1869. These exhibits were all completed in November, 1861, and sent in with a tender.

S. J. REEVES.

Sworn and subscribed before me this 6th day of January, 1870.

JOHN RODGERS,
Examiner.

158 GEORGE WALTERS, of Phœnixville, being duly affirmed according to law, saith:

Question 1. What is your age, occupation, and residence?

Answer. My age is fifty-nine years; am mechanical engineer by occupation, and reside in Phœnixville.

Q. 2. How long have you been connected with the business of the rolling of various forms of iron?

A. I came to Phœnixville in 1838, and have been devising plans for rolling various shapes of iron since 1844.

Q. 3. What form of post is best qualified for resisting vertical pressure?

A. I consider a cylinder the best qualified for that.

Q. 4. Are you familiar with the patents and specifications therein, one granted to Mr. Linville in 1862, and the other granted to Mr. Reeves in 1862?

A. I think I am. I read Mr. Linville's patent over several times, and Mr. Reeves' frequently.

Q. 5. Taking two posts, one constructed according to Mr. Linville's patent of 1862, and one according to Mr. Reeves' patent of June, 1862,

which approaches more nearly to that form which you have said is the most perfect form of a post?

A. I should think Mr. Reeves' post forms the nearest approach to forming the circle of the cylinder, because the parts in that are perfectly connected, and thereby form the union in the circle.

Q. 6. As a mechanic, point out the differences between the columns as described in Linville's patent of 1862 and Reeves' patent of 1862.

A. The difference between the columns is, that the form in Reeves' is nearer the cylinder than Mr. Linville's, Mr. Linville's being disconnected in the circumference, thereby forming but a partial union, while in Mr. Reeves' it forms a perfect cylinder in the column.

Q. 7. State if there is any, and what, difference between these two in respect of the manufacturing of the parts composing the column.

159 A. The difference in the manufacture of those columns is, that Mr. Reeves' column can be manufactured in any mill to suit the present wants of engineering, while the column of Mr. Linville, being but in two pieces, cannot be manufactured but within a very small limit; while it is formed in two pieces the column in the present wants of engineering cannot be manufactured by any mill at present built in this country.

Q. 8. Is it part of your business to ascertain from written descriptions or directions how to make articles thus described?

A. That is my business.

Q. 9. Take in your hand Mr. Linville's patent of 1862, and tell me what there is there to suggest to the manufacturer the form of the parts, or the modes of uniting those parts, composing the post known as Reeves' post, patented in 1862?

A. There is nothing in them that I can find out that would apply.

Q. 10. What is the effect upon the power of the post to resist vertical pressure of uniting the several parts by long rivets through the body of it, as employed in Linville's patent of 1862?

A. The effect is, weakness in the column for want of the parts being braced together; the rivets uniting the two pieces are similar to a chain, in a great measure; they form no part of the brace, which is essential to make those two pieces into a form to resist compression.

Q. 11. Take Mr. Linville's patent of 1865 in your hand and then state, as a mechanic, in what the improvements upon the post consist, as described in his patent of 1862.

A. I don't consider the improvement in Linville's patent of 1865 to be any improvement of that of 1862, because it is the same in effect as Mr. Reeves'—the parts having flanges, the same as Mr. Reeves', and the mode of separating is described in Mr. Reeves' the same as practiced in Mr. Linville's.

Q. 12. Look at the drawing marked "January 28th, 1870, No. 1," and "No. 2" of same date. Were those drawings made by you?

160 A. Yes, sir; they were completed on the days as the drawings show.

Q. 13. When were the designs exhibited in those drawings first made?

A. I went to the site in February, 1860, to examine the old bridge; it was from that day to the time this was completed that I designed various drawings for this bridge, and finally concluded to adopt this plan, on which I made an estimate.

Q. 14. Do those drawings exhibit designs for independent posts composed of two T-bars, placed back to back, sprang in the middle, the tension-braces between them?

A. They do. I was the draughtsman for all the drawings of this set for that bridge.

Q. 15. When you made those drawings was the use of two pieces of iron united together longitudinally, as a post, a novelty?

A. I did not consider it so. Angle-bars and T-bars were nothing new; they were in common use as posts, single and combined.

Q. 16. Look at Exhibits H and I. Who made those drawings?

A. I made them.

Q. 17. Had they any reference to any proposed work or estimates for work?

A. They had. It was a bridge designed of 320 feet span. The section of this chord is 120 inches. I drew this out to show the comparison between the use of a number of pieces and two pieces to form a chord. One of them (I) we can manufacture in our mill at Phœnixville—an ordinary rolling-mill. The column in two halves (H)—I don't know of any mill in this country that can make that.

Q. 18. What would be the minimum expense of preparing the Phœnixville works to make a chord or column composed of two pieces of that size?

A. It would take some time to answer properly. A mill to make this chord, which has nine different sizes of sections, varying from 120 inches in section down to 36, the minimum, would require at least $100,000
161 to form the train of rolls and engine, besides the construction of the mill-house, the necessary heating-furnace, and all appendages connected therewith. Besides fitting the mill for practical use, it would require from $90,000 to $100,000 more. Those rolls, to make these different sizes, would alone cost $30,000 to $35,000 at least.

Q. 19. If made on the plan shown by Exhibit I, what additional expense to the present plant would be requisite?

A. I could prepare the rolls for making that, completed, for about $6,000, for all the sizes therein named that are required for that chord. I consider that the full amount.

Q. 20. If you were given an order for columns or chords of this size in character, and the specifications of Mr. Linville's patent of 1862 as instructions to assist in the manufacture, how would you have gone about to execute the work under those instructions?

A. My answer would be, I could not make them.

Q. 21. Would there be any real union of parts of a column of twenty inches of diameter, composed of more than one piece, if united as in the plan suggested by Mr. Linville in his patent of 1862?

A. They could not be united so as to make a union of it; at least, I do not see any way in which I could do it.

Q. 22. Was the plan of forming columns by breaking up the sections into several parts, and the use of flanges to fasten them together, known to the trade prior to Reeves' invention?

A. I did not know of anything of that kind before Mr. Reeves' invention; did not hear or see anything of the kind in any published books.

Q. 23. Have you made it your business to examine publications on such subjects as they are made?

A. I have examined some few works. I have not made it a general business to examine them. I have examined Humber and several French works that we have in our office. I saw nothing relating to Mr. Reeves' column in any of them.

Q. 24. What particular advantages do you obtain in constructing a column upon the plan suggested in Reeves' patent?

162 A. According to the laws of mechanics known to every engi-

neer, the diameter of a column should bear a certain relation to its height to give the best results, and be suited to such parts designed in the construction of the work. Mr. Reeves' column admits of being shaped to any such designs, at a very nominal cost.

Q. 25. If a column can thus be enlarged indefinitely as to diameter, what advantage does this plan possess in the mode of combining or fastening the several parts?

A. Posts being composed with flanges, the parts can be united by rivets to meet the required strength in the construction, and at very moderate rate of cost.

Q. 26. What were the points in which Mr. Reeves' plan, in his patent of 1862, were new?

A. The posts having flanges in the direction of their length, and being capable of being united by rivets or bolts, with their flanges joined together or separated, as the case in design might require.

Q. 27. Where, before you saw his plan, did you know of a plan for making columns by breaking up the sections in more than two pieces?

A. I have never seen a plan, before Mr. Reeves', in which the columns could be constructed so as to form the circumference in a circle or polygonal shape, so as to bring the part into a perfect unit.

Q. 28. I infer from your answer that that also was a new suggestion; am I right?

A. That was a new suggestion, so as to bring those parts of more than two pieces into the periphery of the circle, so as to form a unit.

Q. 29. Do you know whether this invention or design—viz, forming the column of several pieces, those pieces having flanges, and riveting through the flanges—is a valuable one?

A. I consider it a valuable invention, as these columns are at present all over the country; our works cannot supply one-half the demand.

163 Cross-examined by Mr. Collier:

X-Q. 30. When was the first column constructed according to the patent of Mr. Reeves of 1862?

A. I think about February, 1863; it may have been before or after that time.

X-Q. 31. Where were the columns made at that time used?

A. They were sent to the Bridesburg arsenal, to Major Laidley; they were made to his order.

X-Q. 32. Were they used there; and, if so, for what purpose?

A. Yes, sir; they were put into a building. This was some time in the summer of 1863.

X-Q. 33. State when and where you first saw a hollow wrought-iron post or column, composed of pieces of iron fastened together, other than of T or angle iron?

A. I think it was some time in January, 1862; curiosity attracted me to see the bridge across the Schuylkill, near the arsenal; it was there I saw the column similar to Mr. Linville's first patent.

X-Q. 34. What examination did you make of that column at that time?

A. Nothing especially; my desire was to see the construction of the bridge, as the Phœnix Iron Company had made a design for a similar bridge to cross that place. I took that down to Mr. Thomson myself, and explained to him the merits of it, and left it with him for his consideration. We had also given a tender for the erection of the bridge. As the Phœnix Iron Company did not get the contract, I had a curiosity to see what design the bridge was constructed of. I went there for my own special gratification.

X-Q. 35. When you say that the Phœnix Iron Company had made a design for a similar bridge, you mean simply they had made a design for a bridge at that place, but of different character, do you not?

A. Yes, sir.

X-Q. 36. At the time of your examination you were informed,
164 were you not, that while the external diameters of the posts in that bridge were the same, that the interior diameters were different?

A. That arose in this way: in glancing over the bridge, I observed to the gentleman who was with me, who I afterwards learned was Mr. Piper, that the columns appeared all of a uniform size on the exterior diameter; that there was additional strength acquired as they approached from the center to its abutment; that this could only be accomplished by increasing the diameters or thickening the metal in the parts composing the column. Mr. Piper said that the parts forming the column thickened as they approached the abutments. The manner of thickening, of course, was nothing new to me. I simply made that remark in the manner of conversation between us applying to the particular subject.

X-Q. 37. I understand you to say that this was the first hollow post, composed of pieces of rolled iron other than T or angle iron, that you had ever seen; am I correct?

A. I think you are not correct. I did not consider that a hollow post, it being composed of two parts separated longitudinally through the middle by parts held together by rivets, with distance-pieces between them, thereby forming a column of two pieces, which I term a skeleton column.

X-Q. 38. State whether, in your opinion, the posts in said bridge are solid or hollow.

A. I consider the posts neither solid or hollow; the parts composing the posts are solid, but, when formed into the shape of a post as they are, form, as I before stated, a skeleton shaft or open column.

X-Q. 39. Suppose the pieces composing said posts were fastened together without being sprung apart, would you consider it then a hollow column or not?

A. I could not consider it a hollow column, for the reason the edges joining one another are not united together; it might be called a hollow shaft, but not in the sense of a column. What I term a hollow column is where the parts are thoroughly united, forming the periphery of the column.

165 X-Q. 40. Then, I understand you that the manner or method of fastening together the parts of a post determines whether it is or is not a hollow post; is that so?

A. I consider the manner of fastening the parts together forms its useful effect; whether it may be called a hollow column or not, depends upon the different construction that different people may put upon that. Forming what may be called a hollow column by two pieces, without uniting the edges so as to bring it into a unit, I could not consider it a hollow column in its true sense; it might be so by name, but not in fact.

X-Q. 41. You have taken out letters-patent yourself, have you not, since 1862, for wrought-iron posts?

A. I have.

X-Q. 42. Are such posts, as patented to you, solid or hollow?

A. They are hollow posts.

X. 43. Are the parts sprung apart, or otherwise, in your posts as patented?

A. In some they are sprung apart; in the post which I term a hollow post they are not.

X-Q. 44. In the post which you term a hollow post, as patented to you, how are the parts fastened together?

A. By a series of internal bands, to which the longitudinal sections are united in such a way to the bands so as to bring those parts into union—the bands coming into tension in the same manner as if they were shrunk on the outside; thus a column being in effect just as if they were hooped; by that means the edges are brought into contact as solidly as the strength of those hoops will give.

X-Q. 45. In one of the forms of posts, as patented by you, the edges of the longitudinal sections have slots cut in them, have they not?

A. Yes, sir; the object being to introduce a distance-piece, so that the parts forming the periphery of the circle are thoroughly braced together, so that, when the column is exposed to any oblique pressure, those distance-pieces with corresponding projections going into those slots shall thoroughly brace the segments forming the column and prevent them from sliding.

166 X-Q. 46. Does a post constructed of pieces as described in your last answer constitute a hollow post in effect?

A. I don't consider it a hollow post; I consider it to come under the head of a skeleton shaft or column.

X-Q. 47. Will you define what is meant by a solid post, as understood by you?

A. I consider a round bar of iron a solid post.

X-Q. 48. Will you now define a hollow post and a skeleton post, respectively, as understood by you?

A. A hollow post I consider where the center is taken out and put on the outside of the circle or column; a skeleton post is where the parts forming the circle are separated one from another longitudinally. The useful effect is this, that in one case those parts are thoroughly united together by those grooved pieces as named before, so as to form a unit at those points, thereby preventing the sliding of the parts when the column is strained obliquely. The other is, where those parts should be united simply by distance-pieces through the center, this union could not be effected whereby this sliding of the parts might be obviated.

X-Q. 49. In the Schuylkill arsenal bridge, as examined by you in 1862, what provision was made to prevent the sliding of the parts of the post?

A. I saw none expressly; to a certain extent the ends might prevent the sliding in the manner in which they were secured to the bases and caps, but the center of the column depended solely upon the rivets and distance-pieces, without any bracing whatever of those longitudinal bars, which is necessary for the construction of the column to produce the desired effect.

X-Q. 50. Did you not also see in said post slots in the edges of the longitudinal sections, with the distance-pieces fitting into such slots?

A. I did not examine it critically; I did not see those slots.

X-Q. 51. Assuming that there are such slots, with the distance-pieces fitting into them, what would be the effect thereof?

A. I don't consider it would have any more effect than if the distance-pieces were not there.

167 X-Q. 52. You think, then, as stated in your answer to cross-question 45, that the slots in the edges of the parts, with the dis-

tance-pieces projecting into them, in your post, will thoroughly brace the segments and prevent sliding of the parts, but that such would not be the result of the slot and distance-pieces projecting into them in the arsenal bridge, built by Mr. Linville. Will you state why this is so?

A. In my column the projections of the distance-pieces into the slots of the segments forming the column are so united by the band internally that the effect produced on the column is the same as if the band were shrunk on the outside of the column, while, as in Mr. Linville's column of 1862, such is not the case. The effect to make it a unit cannot be produced by that construction.

X-Q. 53. Have you seen and examined said arsenal bridge since 1862?

A. I have not.

X-Q. 54. Your opinion, however, of that bridge, as derived from your examination in 1862, is not favorable to the character of posts as employed in it; is that so?

A. The character of the post I do not consider a good one; the construction of the bridge I consider good, with that exception.

X-Q. 55. Assuming that, for eight years past, said bridge has been subjected to heavy strains upon it of railroad trains without injury, would you still entertain an unfavorable opinion as to the utility of the posts in it?

A. I do not wish to be understood to condemn the posts in the construction of that bridge for that particular purpose, as two T-bars, placed back to back by separators, would produce the same effect; but, taking the post in its general sense, which comes under the head of general engineering for bridges and other superstructures, I don't consider it a good column, for the reasons which, I think, have been heretofore stated by me.

X-Q. 56. Will you please state why you do not intend to condemn the posts in that bridge, and yet mean to condemn it as employed in other bridge structures?

168 A. The duties said posts have to perform in that bridge are very small, in comparison to what columns are required at the present day in large bridges, such as one now built at Louisville, Kentucky, for which the Phœnix Iron Company furnished columns some fifty feet long. To replace those columns furnished by the Phœnix Iron Company by columns made similar to those of the arsenal bridge, I think would be next to impracticable.

X-Q. 57. What, if anything, does the fact of said arsenal bridge having withstood without injury, for eight years past, heavy railroad travel upon it, prove as to the unity of the posts forming part of it, and the absence of mobility of the parts composing said posts?

A. As I before stated, the sizes of those columns answer the same purpose as two T-bars would for the same object; therefore they may be perfectly secure, and no doubt are secure, for the object which they have to fulfill.

X-Q. 58. Cross-question 57 repeated.

A. If those columns were united at the edges to make them a thorough unit, such as the Phœnix Company's columns are, they would stand the pressure which is then imposed upon them. I do not think it proves anything as to the unity of the post.

X-Q. 59. When were posts, as patented to Mr. Reeves in 1862, first employed in bridge-construction, so far as you know?

A. I think at least four or five years back, perhaps longer. I can't say in what bridges they were applied.

GEO. WALTERS.

Affirmed and subscribed before me, this 28th day of January, A. D. 1870.

JOHN RODGERS,
Examiner.

JOHN GRIFFEN, a witness on part of complainant, being duly affirmed according to law, saith:

Question 1. What is your occupation and residence?

169 Answer. My residence is at Phœnixville; my occupation that of general superintendent of the Phœnix Iron Works.

Q. 2. Are you skilled in the art of rolling iron in the various forms in which iron is thus prepared for use?

A. I have spent almost all my adult life in the manufacture of iron, and during that time have prepared rolls for and have rolled certainly as many different forms and difficult shapes of iron as any other mill-manager in the country, both at Phœnixville and elsewhere.

Q. 3. What is the earliest period of time that you can recollect of seeing a post, or a plan for a post, composed of more than one piece of wrought or rolled iron united together?

A. I saw drawings of such posts, and such posts used as stiffeners made of two T-bars, between 1856 and 1862, at Phœnixville.

Q. 4. Look at the book entitled "Iron Roofs of Recent Construction," volume 124 of the rudimentary treatise, published by John Weale, in 1859, text-page 7, and plate No. 7, and state whether or not you do not there find a description and drawing of a post composed of four angle-bars, separated and united, swelled in the middle or sprung apart, used and employed as a post for support of a roof.

A. The drawing exhibits a section of four angle-bars, set apart by a distance-piece made of cast iron, the distance-pieces being about equidistant from one end to another, the post being sprung apart, or swelled in the middle, and the four angle-bars united through the distance-pieces by bolts; the whole intended to form, so put together, one post. The drawing is plate No. 7, and the section referred to is marked *a a*, and the parts themselves are shown in Figure 1; the Figure 1 exhibits the section of an iron roof over the New Street Station, Birmingham. A description of the post will be found on page 7 of the letter-press accompanying the same work.

Q. 5. What form of post is best adapted for resisting vertical pressure?

A. I have always supposed a cylinder to be the best.

Q. 6. Are there certain known formulæ or data for determining

170 the power of resistance of posts, and what are the elements or data of calculation, assuming the material to be of the same in all cases?

A. In ascertaining the strength of any particular form that is ordinarily tried to its ultimate strength, it is generally tried of various lengths, as compared with its diameter, the neutral lines of that form of iron is taken as nearly as possible, and from these respective trials the strength of that particular form of iron for the different lengths of posts are worked out. The value of that post, however, depends very much upon the kind of iron of which it is composed. Clarke, in his experimental operations previous to the erection of the Britannia bridge, made a great many experiments upon wrought iron; some of the pieces experimented upon were cylindrical, some were square, some were rectangular, being about twice as long as wide. Some of these rectangular pieces were divided in the middle, and some of the squares were divided

into four cells. In all those trials it was found that the cylinder was by far the strongest form; the squares increase in the strength per square inch, in nearly the ratio of the thickness of the iron forming the sides. In the cylinders the thickness seemed to have very little to do with it, the strength remaining about the same per square inch of section. Experiments have also been made by numerous parties upon T-iron, angle-iron, and other irregular forms, for the purpose of ascertaining their value for posts or struts, but in all cases they have been found very far inferior to circular forms. There are printed formulæ, familiar to engineers, by which the strength of any given post can be calculated, as far as it is wanted, for his purposes.

Q. 7. Given, a column of a certain height and diameter, is the ratio of increase of resisting power in the direct ratio of the increase of the diameter?

A. It would be considerably more than four times as strong for a solid cylinder; because, first, it is twice as wide one way and twice as wide the other, forming the square; then, as it is shorter, the tendency to pass out of line vertically is less, about as per Gordon's formula.

171 Q. 8. What is the effect for resisting the strain of compression, placing the material of which a post is composed near the circumference instead of at the centre, thus forming a hollow cylindrical post, as compared with the same quantity of material formed into a solid cylindrical post?

A. It makes the hollow post very much stronger than the solid post.

Q. 9. Look at the paper before you, (marked J. R., February 1st, 1870,) and say does that paper contain the formula and the table by the use of which the strength of columns made as directed by Mr. Reeves' patent of 1862 can be ascertained for any particular diameter, section and length?

A. I believe it to be the only formula used by engineers for calculating the strength of cylindrical posts, whether of cast or wrought iron. I know from actual trial that this is under the strength, simply because it starts, I think, at 4,000 pounds too low. This is an English formula, and was worked out from trials on English iron, which is softer than American iron. *F* should be 40,000 instead of 36,000. I know that from the experience of eminent engineers of this country. I have seen specifications where they have required iron to stand 45,000 pounds per square inch. I refer particularly to the specifications for the St. Charles Bridge Company, Missouri.

Q. 10. Are you familiar with the two patents, Mr. Linville's of January, 1862, and Mr. Reeves' of June, 1862?

A. I have seen both patents, and have read them carefully, and I think I understand them.

Q. 11. You have seen the models of posts made according to these directions which have been exhibited in this cause, have you not?

A. I saw them at Mr. Collier's office.

Q. 12. Taking two posts, one made of two pieces, as directed in Mr. Linville's patent, the parts being united as therein directed, and the post made according to Mr. Reeves', fastened as therein directed, point out, as a mechanic, the points of resemblance and the points of difference between those posts, and also the relative advantages and

172 disadvantages of those distinctions.

A. The only thing in common between them is, that they are both composed of wrought iron; to the eye of a casual observer one would seem to be a cylinder with flanges, and the other would seem almost to be nearly a cylinder swelled in one direction, or more nearly

octagonal. When examined critically, or as a mechanic would examine it, they are found to be very different. One is rolled semioctagonal, or nearly so, two such pieces being united by bolts or rivets passing through the body from one piece to the other, and separated or kept apart by castings placed between the two pieces. The other is made of quarter or other portions of a circle, more than two, so far as the body of the column is concerned, with flanges on each side of each piece; the pieces are then united together to form a column, by uniting the flanges together with rivets, or by inserting washers or ferrules between the flanges, thus uniting the whole and making the column a unit; the one being swelled in its general outline in one direction, and the other being parallel, or nearly so. As to the advantages and disadvantages: in Mr. Linville's column, as covered by his patent of 1862, the two pieces of semioctagonal iron, which are intended to form a post, are united together by rivets or bolts of very considerable length; and, having but comparatively small cross-sections, the result is that the two pieces form two independent posts, receiving very little support from the rivets or bolts fastened to them; they therefore ought, upon trial, to obey the laws of two such pieces of iron tried independently of their being secured together; whereas Mr. Reeves' column, under his patent of 1862, from the fact that the flanges are either brought in contact and riveted firmly together, or upon washers or ferrules, should obey the laws due to a solid cylinder, the rivets forming the whole into a unit, and preventing one piece moving without taking the other with it.

Q. 13. What is the relative effect of columns composed in those different forms by increasing the diameter of such columns?

A. If my interpretation of the law is correct, then the further the two pieces are spread apart the weaker they become, because
173 what little strength the short bolt gave is reduced as the length of that bolt is increased, there being no trussing provided for in that column. With Mr. Reeves' column, on the contrary, the whole being riveted firmly, its strength is increased per square inch of section by an increase of diameter.

Q. 14. You have read, have you not, the testimony in this cause as to the experiment made with Mr. Linville's column of 1862, and the fact, there stated, that the deflection took place in the line of the largest diameter of the column?

A. I heard the testimony given by Mr. Piper, in which he stated that it did give way in the long diameter.

Q. 15. Is not the law which you have stated verified by the result of this experiment?

A. I think it is, fully.

Q. 16. State if there is any, and what, difference between these two posts in regard to the manufacture of the sections or parts of which they are composed.

A. I suppose that in any rolling-mill in this country Mr. Linville's post would be limited to a diameter of about twelve inches; that gives a depth to the piece of about six inches. The other post (Mr. Reeves')—we are required to make a post whose section contains $189\frac{4}{10}$ square inches, and of a diameter in the body of twenty inches, which we expect to make in our rolling-mill, with rolls less than nineteen inches in diameter to the pitch line. We can make them of almost any required size and length. We have rolled pieces as long as fifty-two feet, and now have quite a large number of columns of our make in the Ohio bridge at Louisville, which contains pieces forty-three feet in length.

Q. 17. What is the relative cost of rolling these semicircular or semi-

octagonal pieces when the chord is eight inches and when the chord is twelve inches?

A. As you deepen the portion of a circle, and just as you widen it out, you increase the difficulties of rolling and the expense of preparing the pile.

174 Q. 18. Is not your capacity to produce lengths practically limited by the widths of the pieces that are to be rolled; or, in other words, is not the capacity of an ordinary, but first-class, mill limited by the size and weight of the pile which is to be rolled into the piece?

A. It is limited more by the breadth of the piece than the thickness; the power required to roll being directly as the breadth, the length of the piece is only limited by the weight of the piles that can be heated; that is upon the supposition the engine has the proper amount of power for the train.

Q. 19. Is it in the line of your business, and are you competent, from written descriptions or directions in respect of the forms in which iron is to be rolled, to instruct your men how to produce the intended result?

A. Yes; it is in the line of my business to give the workmen such information as will enable them to prepare the rolls and produce such forms of iron as are required. I am not in the habit of doing it at Phœnixville, as we have a man there whose special duty it is to do that kind of work.

Q. 20. Are you not the inventor of an iron beam known as the Griffen beam?

A. I am the inventor of the pile or mode of making the double-flanged iron beam used in the construction of bridges, houses, &c., and the designer of the rolls from which they were made.

Q. 21. With the directions contained in Mr. Linville's specifications of January, 1862, would you have any difficulty in constructing a post such as is there described?

A. No, sir; because his specifications include the drawings.

Q. 22. Is there anything in those specifications or drawings which would enable you or any person skilled in the art to construct a column which is described in Mr. Reeves' patent?

A. I should think not; it would not enable me to do so, nor, I think, any one else.

Q. 23. Are you familiar with Mr. Linville's patent of 1865, so far as it relates to the improvements on his post, as described in his patent of 1862?

A. Yes, sir, I think I am.

175 Q. 24. What distinction is there between the changes or improvements which he has suggested in that patent, and points which are peculiar to Mr. Reeves', as described in his patent of June, 1862?

A. I understand Mr. Reeves' patent only covers the shaft; whereas Mr. Linville's covers both the head and foot of his in connection with the shaft. So far as the shafts of the two are concerned, they may be said to be exactly alike; there is a slight difference in the outside of the form of the body—one having flat surfaces upon it, the other being in the form of a circle; the flanges, however, are precisely the same. The mode of fastening in Mr. Linville's seems to be confined to the swelling out at the centre and inserting the ferrules between the flanges, securing the whole together with rivets; whereas Mr. Reeves' seems to describe a straight column, with the flanges brought in contact and riveted, or with ferrules interposed, with rivets passing through the fer-

rules and flanges; the object of the separation in both cases being expressed to be the ability to pass diagonal rods through the opening thus left.

Q. 25. What is the effect on the power of resistance of a post composed of more than one part, of swelling in the centre by separating those parts, and thus deflecting the parts from a right line?

A. I do not think it would add, or probably diminish, materially from the strength; while it gains a little in breadth, and thus would apparently strengthen, the strain is not coincident with the lines of the iron; therefore the iron will not resist so much by the secant of the angle, whatever that may be. It would not be near so strong as the same post, if properly secured and set apart uniformly from top to bottom; because, aside from the loss due to the obliquity of the iron, the breadth of the base and top are both diminished, and it would approximate then the law of round ended columns.

Q. 27. You have spoken of a column to be used as a top chord in bridges, which is to be twenty inches diameter in the body; state what additional expense is requisite to manufacture that column at Phœnixville, with its present plant.

176 A. To make the different thicknesses used, from that size down, would require the making of one set of three high rolls to prepare the iron, and one set, having five separate finishing grooves of two high rolls, involving a cost of about $2,500.

Q. 28. What would be the additional expense required to manufacture that chord or post, if made of not more than two pieces?

A. So far as we are concerned, it would require the construction of an entire new mill; the power required would be indicated by an engine of sixty inches diameter and five feet stroke. It would take three sets of housings for rolls, each set wide enough apart to take in rolls of not less than seven and a half feet in length. It would require boilers to give power, a little, if any, short of 1,100 horses. It would require the necessary and very large heating-furnaces, and, of course, the mill-building, and proper fixtures. To roll the different sizes required, from the thickest down, would require several duplicate sets of rolls, three sets being required for each size. The cost of such a mill, with the necessary machinery, would not be much, if any, less than $300,000. The rolls alone would be worth between $40,000 and $50,000.

Q. 29. What would be the effect as to the intended purpose of such a column, if made of two pieces, upon Mr. Linville's plan of 1862, in two parts, fastened together by rivets across the diameter, as directed in his patent?

A. If made considerably heavier than the specifications required, they would probably answer the purpose, simply because that each piece acts independently of the other.

Q. 30. Did you ever, prior to Mr. Reeves' invention, hear of a mode of making a column of rolled iron by breaking up the shaft into sections of more than two pieces?

A. I don't know that I did; I don't remember to have done so.

Q. 31. Was that invention of his, in your opinion, a novelty at the time it was invented by him?

A. It was.

Q. 32. Do you know whether that mode of constructing posts has been extensively adopted since his invention?

177 A. So far as we are concerned, we are very busy making them, and have made a great many of them, and continue to do so in large quantities.

Q. 33. In your opinion, is that invention of his a valuable one?
A. I consider it a very highly valuable one.

Cross-examined by Mr. Collier:

X-Q. 34. Have you read the testimony of Mr. Reeves heretofore given in this cause?
A. I have.
X-Q. 35. Does not Mr. Reeves, in that testimony, refer to columns or posts of rolled iron composed of more than two pieces, and used prior to the time of his alleged invention?
A. Yes, sir; he refers to posts made of more than two pieces—to four angle-irons.
X-Q. 36. In the work to which you have referred in your examination-in-chief, viz, "Weale on the Construction of Roofs of Iron," is there not shown a post or column composed of four pieces of rolled iron?
A. Yes; he shows a post made of four pieces of angle-iron rolled.
X-Q. 37. Then, the fact of the making by Mr. Reeves of a post of more than two pieces of rolled iron was not, in itself, a new invention, was it?
A. It was not, simply in itself, as four pieces of iron had before been used.
X-Q. 38. In the references cited in the testimony of Mr. Reeves is not the use shown, prior to his alleged invention, of four pieces of rolled iron united together by rivets through the flanges of such pieces, the same being employed as posts for columns?
A. I do not know of any, except those used as distance-pieces in the work of Weale. The rivets or bolts can hardly be said to go through the flanges, although they go through the bottom of the bar, but
178 an angle-bar may be said to be all flange. The angle-bars are set with the apex of the right angle toward the centre, the distance-pieces resting against that apex.
X-Q. 39. Have you seen the work cited by Mr. Reeves in his testimony, (page 27,) entitled "Practical Treatise on Cast and Wrought iron Bridges," &c., by Wm. Humber, 1857, Plate 35, and Figures 1, 2, 6, 7, and 8, and Plate 37, Figures 1, 3, and 5?
A. I have seen it before, and I have it before me now.
X-Q. 40. Will you state of how many pieces the struts or posts, as shown in said work, are composed, and whether they are not fastened together by rivets and bolts through the flanges?
A. Figure 6, marked *b b*, being the section of the first main brace in the viaduct, as in Warren & Kennard's patent, Londonderry and Enniskillen Railway, consists of three flat bars laid together, having a T-bar on each side, the whole riveted together through the flanges of the T-bars throughout the length of the strut. The second brace (Figure 7) is made precisely like the first, except the iron is somewhat lighter. The third brace (Figure 8) consists of one bar central, with a T-bar on each side of it, riveted in the same manner as the two preceding. Figure 9 has one flat bar and one T bar riveted together in the same manner.
X-Q. 41. Calling your attention to said work of Humber, cited by Mr. Reeves, Plate 38, Figure 12, do you not find a post composed of four pieces of rolled iron, with flanges on their edges, and united together by rivets or bolts through such flanges?
A. I find Figure 12, section *i, k*, one bar of flat iron, with two bars half the width set at right angles to it; four angle-irons then being united in the four corners; the whole then riveted together, the rivets

passing through the flanges of the angle-iron and through the flat bar; the whole forming a cruciform figure, as seen in section.

X-Q. 42. Then, I understand you to state that you do find a description of a post composed of four pieces of rolled iron, having flanges upon their edges, and united together by rivets passing through their flanges?

A. I find four pieces of angle-iron and three pieces of flat iron,
179 the whole being secured together by rivets passing through the flanges of the angle bars and through the flat bars, the whole forming the cruciform figure, as above described.

X-Q. 43. Then you do know, anterior to the alleged invention of Mr. Reeves, of posts composed of more than two sections of rolled iron?

A. Yes, sir.

X-Q. 44. Such being the case, will you state what, in your opinion, is the novel feature, if any, of the post, as described in the letters-patent of Mr. Reeves?

A. It is the rolling of a piece of iron containing the flanges, with the body portion either straight or circular connecting the two flanges, making the whole, when riveted up through the flanges, as described in his patent, a hollow post; or, more properly, his invention consists in throwing the largest amount of metal possible to near the periphery of the column, and using the flanges just sufficiently large to secure it properly with rivets.

X-Q. 45. I understand you, then, to state that its novelty does not consist either in the use of more than two pieces, or in the employment of flanges on said pieces, and the riveting through such flanges; am I correct? and that such features were employed prior to the invention of Mr. Reeves?

A. To each of those propositions, separately, I should answer, it does not consist in either of said features; neither of those is his invention; neither the making of colums of more than two pieces, nor riveting through the flanges.

X-Q. 46. The novel feature of his invention, as understood by you, consists in throwing the largest amount of metal possible near the periphery of the column, so as to make a hollow post; is that so?

A. It is so when connected, as Mr. Reeves' is.

X-Q. 47. And if a post is composed of any number of pieces more than one, united together by any means, so that the parts shall act together, and not independent of each other, the metal being distributed near the periphery, will not the same effect be produced and the same principle pertain to all?

180 A. The same effect will be produced if the article is round, or nearly so, and the same principle, of course, will pertain, as a mechanical device, if it accomplished the purpose mentioned in the question, to wit, "the whole being formed so that one piece shall not act independently of the other."

X-Q. 48. In the patent of Mr. Linville of 1862, what provision, other than the bolts or rivets passing through the body of the post, do you find for preserving the unity of the post and to compel the parts thereof to act together?

A. I have not been enabled to find anything. I notice that distance-pieces are used, which act as struts from keeping the two pieces coming nearer together than they are intended to come.

X-Q. 49. What would be the effect, in this particular, of decreasing the distance between the distance-pieces?

A. The oftener you put a bolt through, and the shorter the length of

that bolt, the greater the tendency to resist bending in the two pieces. The more of such bolts put through in a given length of column, the greater would the tendency of the two pieces forming the column to act independently of each other be counteracted.

X-Q. 50. You do not find in the letters-patent of Mr. Linville any limit as to the number or distance from each other of the distance-pieces, do you, or the width of such distant pieces?

A. So far as my memory serves me, no.

X-Q. 51. Would not the unity of the parts of the posts be approximated according to the number of said distance-pieces, their distance from each other, and their width?

A. Certainly; the greater the number of distance pieces and rivets in any given length of column, the diameter of the column remaining the same, the nearer it would approach unity.

X-Q. 52. Do you not find, also, in said patent, that the extremities of the columns are brought together so as to form a true cylinder or polygon, and then that the parts are united together by bases and caps cast around them?

A. Yes.

181 X-Q. 53. The extremities being thus fastened together so as to prevent the pieces from moving at the ends, can the pieces slide or change their relative positions at any intermediate point between the extremities?

A. The figure formed by the column, which would be straight before pressure, would depend how the face is applied to the top and bottom. If applied directly in the line of the column, either centrally or throughout its whole base, the pressure being equal on each side, the pieces would be likely to take slightly the form of the bowed side of the letter D. If, however, the strain was applied on one side of the column below and the opposite side above, it would approximate slightly the form of the letter S.

X-Q. 54. The question 53 contemplated the fastening of the post not only at the ends but at intervals through the body of the post, as described in Mr. Linville's patent of 1862; and with this understanding will you please answer said question?

A. With the same understanding my answer would be the same; all columns would obey the same law.

X-Q. 55. Do you not understand it to be the object of the invention, as described in Mr. Linville's said patent of 1862, to secure and preserve the conjoint action of the parts, or, in other words, to secure unity?

A. I suppose, myself, using it as a post, that would be the object.

X-Q. 56. Assuming, as matter of fact, that the method of attachment of the parts as described in said patent are effectual and sufficient to secure the conjoint action of the parts, I will ask you to state whether you do not find in said patent the feature which you have stated in your answer to cross-question 44 as being the novel feature of the post as described in the patent of Mr. Reeves, to wit, the throwing of the largest amount of metal possible near the periphery of the column?

A. Yes.

182 X-Q. 57. Assuming the fact, as stated in the last question, as to the practical efficiency of the attachments in Linville's patent of 1862, will you state whether each and all of the references to prior inventions, as cited by Mr. Reeves in his testimony and by yourself, do not differ from the inventions as described in Linville's and Reeves' patents, respectively, in this important particular, to wit, that in such

prior posts the mass of the metal is disposed near the center of the posts, whereas in the others it is disposed near the peripheries?

A. I would answer that they do differ exactly as stated in the question; the only exception to that is the putting together, to act as struts, two bridge-rails, riveted together through the flanges; they were used as arches in bridges on the Pennsylvania Railroad.

X-Q. 58. How was the pressure applied on the struts, as referred to in the last paragraph of your last answer, and wherein did it differ from the mode of application of pressure to posts or columns?

A. It differs in this, that in the case of a post the pressure is applied directly at the end of it and resisted at the other; whereas in the case of an arch the pressure is applied at frequent intervals transversely; this transverse strain is, by the stiffness of the arch, transmitted through its length to the points of support. A familiar example is seen in wooden structures, in what are termed Burr bridges.

Re-examined by Mr. McMurtrie:

Q. 59. Is an angle-iron a bar with flanges on its edges; if so, what part is bar and what part flange?

A. It is all flange; it has no body separated from the flange.

Q. 60. If a post be made of combined angle irons do you not lose all the capacity of increasing the diameter; or, if you increase diameter, do you not lose unity; or, if by filling pieces you gain unity do you not lose the benefit of the hollow cylinder?

A. Most certainly you lose the benefit of the hollow cylinder; and it is very difficult to get a large diameter by the use of angle-irons.

183 Q. 61. When the cruciform figure is used as a post, with flat bars and T-bars combined, is not the bulk of the material thrown into the centre?

A. Certainly it is.

Q. 62. Is that figure anything more than a ribbed flat bar, or a flat bar with buttresses?

A. I should say it was not a ribbed bar with buttresses, and differs from a flat bar ribbed.

Q. 63. Can you make a hollow column with any number of pieces of angle-iron?

A. I do not know how I could form a hollow column with angle-irons at all.

JOHN GRIFFEN.

Affirmed and subscribed this 1st day of February, A. D. 1870.

JOHN RODGERS,
Examiner.

APRIL 12th, 1870.

Present: Mr. McMurtrie, Mr. Collier.

JOHN W. MURPHY, a witness for the complainant, being duly affirmed, saith:

I am forty-two years of age, and am a civil engineer and bridge-builder by profession.

Question 1. What experience have you had as constructing engineer of bridges and other structures, in which Mr. Reeves' iron post can be used?

Answer. I have been engaged in the business of bridge construction and the designing of iron bridges for over twenty years. The first iron bridges that I had any knowledge of were those designed by S. Whip-

ple, of Utica, New York, who patented in 1842, if I remember right, an arched bridge of cast iron, with linked chords and a cast-iron pin,
184 the diagonals of which, to resist unequal loads, passed through the pin with bosses, nuts, and screws. Mr. Whipple also devised a trapezoidal truss bridge about the year 1846, with a top chord of cast iron, posts of cast iron, with girder-rods about them to resist lateral flexures; a chord of links and cast-iron pins, with openings for diagonals. All his posts were of cast iron. After building a number of these bridges I found it was desirable to avoid, if possible, the use of cast iron for the link chord-pins. With that view, I devised in 1859—afterwards perfected in 1860, and patented in 1861—a device for an eye-bar chord, diagonals of eye-bar construction, with a post of cast iron, with openings to admit the diagonals. See my patent of April, 1861. The claim in this case refers, however, only to the counter. At this point in the affairs of bridge construction, a post, vertical or column member of wrought iron, was found to be necessary. I had made the column of cast iron, with girder-rods—the column in two parts, divided and swelled at the center to admit of the passage of the diagonals through the post. Yet cast iron was an objectionable material, liable to fracture by any accidental blow; and, although no accident had occurred from its use, it became a matter of grave consideration among railroad men of prominence, as to whether a wrought-iron post should not, or could not, be devised to take the place of my post in the Murphy-Whipple bridge, which was constructed in part of cast iron. A conversation had with John Edgar Thomson in the fall of 1859, on which occasion I was showing him my plans, developed to my mind, from his reasoning, the necessity for a wrought-iron post. I spoke to him of the impossibility of getting any forms for such a post without great expense; he suggested to me two channel-bars—a device which I afterwards carried out. Mr. Reeves' post I am familiar with; I am now putting it in my bridge across the Wissahickon, Philadelphia, for the water department, and expect to put the post, as devised by him, in my design for the South-street bridge—a work which I am now executing.

Q. 2. Are you familiar with that post as described in his patent of 1862?

185 A. I am. I am acquainted with its use for fire-proof buildings, and for a great many other uses, such as any ordinary column of cast iron would be employed for, with this difference—the wrought-iron column of Mr. Reeves has a greater capacity to resist flexure—the cast-iron column a slighter capacity therefor. Reeves' wrought-iron posts can be used in all cases where a thrust strain is imminent, and, indeed, when a tensile strain occurs, it is as good as any device can be made. The use of it for the diagonals of the Warren girder prove this fact, since they act reciprocally by thrust and by tension.

Q. 3. Was that post, as described in his patent of 1862, a new invention at that time; if so, in what did its novelty consist, and what are its peculiar advantages—first, in a theoretic, scientific sense, and, second, practical?

A. I examined Mr. Reeves' patent as soon as he developed it and offered it to the public. I believe it to be new. I think I gave then my unqualified assent to its claim to fill what was wanting in the construction of those parts of bridges that necessarily resist thrust strains. To decide what the proper form of a column is to resist thrust strains, we practically ask—first, what is its capacity to resist lateral flexure, since we know that the strength of all columns, theoretically, is as the fourth

power of their diameters, and inversely as the squares of their lengths, and these elements by their areas; and since these three are the elements of the transverse value of beams, differing only in their powers, we therefore know that any column to resist in the greatest degree a thrust strain must have in the greatest degree a capacity to resist a transverse strain; that is to say, if it is proposed to test a column, lay it down, each end being supported, and hang a weight at the centre; revolve it about the axis of its supports, the weight being constantly attached; now, if the deflection be equal for every point of its revolution, this will be a perfect column, and its value to resist compression will be the greatest in proportion to its area of section. A perfect cylinder, it will be seen, will fulfill these conditions. Now, any wrought-iron column, to be a good one, must fulfill these conditions by
186 approaching as near as possible to the theoretic form of a perfect cylinder. Reeves' column does this, in my mind, as near as it is possible for a column of wrought-iron segments, without side flanges, to do. The segments being flanged, with filling pieces between them, closely riveted to the flanges, gives, in effect, a greater diameter to the column than the main segments would do; the flanges of these segments give a theoretic line from point to point of the riveting, which in practice gives greatly increased strength, because it is, in effect, an increased diameter; therefore, the greater the number the parts of a column, the more closely will this extreme diameter approach to an increased size of cylinder, since the strength of a column varies very nearly with a fourth power of its external diameter.

Q. 4. What advantage results from the mode of fastening the pieces together through the flanges?

A. The advantage resulting from that mode of fastening is the same as would result from closely riveting all the parts of a girder together. We would not think, for instance, of uniting the top and bottom flanges of a girder together by means of a vertical bolt, with ferrules; the ferrules would, dependent on their length, have some value of resistance to diagonal and vertical pressures, but they would be poor devices to resist transverse strains. The advantage, therefore, of close riveting over a ferrule is as a maximum, so to speak, to a minimum of value; the close riveting is the best condition; the value of the ferrule varies inversely as its length—that is to say, the longer it is, the weaker the form of construction that it gives support to.

Q. 5. What advantage is there in the use of more than two pieces to form the body of the column?

A. In reply to this question I have only to repeat what I have said in effect before, that the greater the number of pieces, the closer, then, is an approximation to a perfect cylinder, on the principle that a circle practically is but a polygon of an infinite number of sides; there-
187 fore, the greater the number of sides or parts that the cylinder is divided into, the closer the approximation to a theoretic condition of a perfect column; the greater the number of parts united by flanges, the stronger will be the column.

Q. 6. Was there any form of post known to the profession at the date of Mr. Reeves' patent by which these peculiar advantages were obtained?

A. This peculiar form of post of Mr. Reeves was new to me. I know of no form of post that so thoroughly fulfills all the practical and theoretic conditions as this does. In all my reading I have found none like it described, and I believe it to be new and original.

Q. 7. If similar contrivances had been suggested by others, whether

in books or in actual use among engineers, was your position such as to render it reasonably certain that they would have come to your knowledge, or is it at all probable that up to this date you should have been ignorant of their existence?

A. It is not probable that they would have passed my information.

Q. 8. Have you examined Mr. Linville's post, as described in his patent of January, 1862?

A. I have; in the arsenal bridge across the Schuylkill River.

Q. 9. Have you read and examined his patent?

A. I have.

Q. 10. Which, if any, of the peculiarities of claims of invention in Reeves' patent of 1862 is contained in that of Linville's of 1862?

A. There is no peculiarity of device in Reeves' patent similar to Linville's, except that Linville's has segments of a circle, and so has Reeves'; but the manner of fastening is totally different.

Q. 11. Is there anything, and, if so, what, in the Linville patent of 1862, which describes or suggests a plan for making a post like Reeves'?

A. There is nothing in Linville's of 1862 that would suggest a post like Reeves'. Linville's post depends upon internal fastenings,
188 so to speak—Reeves' upon external; unless you say that a wood post would suggest a cast-iron one, and a cast-iron one would suggest a wrought iron one, and so on. If it is a certain peculiarity of construction, of the same kind of material, that makes the difference, the two to perform the same function in the bridge, then the Reeves post is novel because it fulfills all the theoretic conditions, while the Linville post does not.

Q. 12. What are the differences, or difference, in the modes of fastening the posts of the columns together, and the effects produced by the modes suggested by Linville's patent and by Reeves' patent of 1862?

A. In Linville's patent of 1862 the outer diameters of the segments in one direction are not fastened at all. In Reeves' column, at all points of the diameter the segments are securely fastened together. For instance, if we were to test the two columns by a weight applied at the centre, transversely, the column supported at each end, we would expect to find the deflections of the Reeves column due to that weight equal for every point of its revolution. If we test, by the same process, the Linville column, we would find that its deflection would be greater in one direction than in another.

Q. 13. What are the differences between these two columns, as to the number of the pieces of which the shaft or body is composed, and the effects or results of such differences?

A. The greater the number of pieces in a column constructed as the Reeves column is constructed, the more perfect it will be. In the Linville column the greater the number of segments it has, the more imperfect it will be.

Q. 14. Assuming that, under vertical pressure, Linville's post yields in the direction of the largest diameter of the combined post, what is the necessary inference in respect of the actual union or combination of the two pieces?

A. If the Linville column yielded invariably in the direction of its greatest diameter, which I reasonably expect it would, the inference would be, that the attachments of the segments one to the other are defective.

189 Q. 15. When you say that the attachments must have been defective, state in what manner, following Mr. Linville's direction

in his patent of 1862, those attachments could be made perfect or better and so that the deflection would not take place in the line of the largest diameter.

A. That could have been remedied by turning up a flange at the point of the approach of the two segments, and riveting the two firm together.

Q. 16. My question was, how it could be done according to Mr. Linville's directions for fastening them together.

A. He could not do it.

Q. 17. Look at Linville's patent of 1865 relative to a post, and point out what claims there are there for improvements, if any, that are, and what are not, identical with Reeves' claim of 1862.

A. Linville's post of 1865 is Reeves' post of 1862, except that Linville interposes ferrules or washers between the flanges; that is all the difference, essentially, that I can see.

Q. 18. What points, if any, claimed by Reeves as novelties or inventions in his patent of 1862, are also described in Linville's of 1862?

A. I can't see that there are any points claimed that are similar.

Q. 19. Have you ever known Linville's post of 1862 to be used except at the arsenal bridge?

A. No, sir.

Q. 20. To what extent, to your knowledge, is Reeves' post of 1862 used, and for what purpose?

A. It is used for public buildings, bridges, fire-proof buildings, and elevated railroads to a very large extent.

EYE-BARS.

Q. 21. Have you ever used eye-bars in the lower chords of any bridges that you have made, and when and where?

A. I have used eye-bars as early as the year 1860 in two spans
190 of a bridge at Allentown; and from that time up to the present in nearly all the bridges I have constructed I have used the same device.

Q. 22. Have you used at the foot of your bridge posts, castings with ribs projecting downwards and resting upon the pin which passes through the eye-bar?

A. I have.

Q. 23. Were these ribs so arranged that the main rods and counters were placed between them in such manner that they had no tendency to bend the pin upwards?

A. They were.

Q. 24. Can you produce the drawings of said construction?

A. Yes, sir, (and the witness produces them, marked by the examiner "Murphy, April 12, 1870, No. 1.") This is the competitive design I made for the bridge at the arsenal. This drawing was made in the fall of 1860.

Q. 25. Mark with a pencil where the use of the eye-bar is exhibited in that drawing, and where the use of the castings with projecting ribs is shown.

A. I have marked on the first plan eye-bars; and on a tracing now produced, marked "Murphy, April 12, 1870, No. 2," the use of the castings and ribs projecting.

Q. 26. To whom was that drawing sent?

A. To the chief engineer of the Pennsylvania Railroad, Mr. Wilson.

Q. 27. When you got it back, had you any reason to suppose, and if so, what, that it had been copied?

A. I had reason to suppose that it had been copied; my draughtsman called my attention to the fact, when it was returned, that there were thumb tack-holes in the corners, which gave evidence that a tracing had been taken from it.

Q. 28. Is there any part of this drawing, and, if so, what, resembling the drawings attached to Mr. Linville's patent of 1862?

A. The only essential difference between the two plans is, that the Linville had a wrought-iron post, with the same essential form of
191 foot to it that I had devised. Another difference is in the form of the first panel. In mine, it was made by a leaning column; in his, the column was vertical. In the diagonals, my bridge had an eye at each end; in his bridge, the diagonals had an eye at one end, and a screw and nut at the top. It was all the essential difference between the two plans.

Q. 29. In what respect do those two drawings differ as to the proposed use of eye-bars?

A. In Linville's bridge, he puts the beams of the roadway upon the eye-bar, which beams were of wood upon the eye-bar, thus supporting the roadway. In my case, I put the beams of the roadway upon the foot of the posts, intending to convey the weight of the roadway directly to the pin.

Q. 30. Produce a drawing showing the ribs with main rods and counters so placed between them as to avoid bending the pin upwards.

(Drawing produced, marked by the examiner "Murphy, April 12th, 1870, No. 3.")

A. This drawing shows the general elevation and ground plan and details of a bridge constructed at Allentown; it is dated October 19th, 1860.

(The detailed drawing of the same date is here produced, marked "Murphy, No. 4.")

Q. 31. What is the section of the eye in those eye-bars?

A. The axis of the bar was square, and the eye of the bar flat.

Q. 32. When they were set, in what direction were the eye-bars set?

A. The eye would stand on edge, of course.

Q. 33. Why did you not set the roadway on the eye-bar?

A. Because I believe it to be bad practice to subject a bar, when under great tensil strain, to transverse strain at the same time.

Q. 34. Have you ever seen a bridge having wide and thin bars in the bottom chord set on edge, in which the platform rested on these bars; if so, where?

A. I have seen a number of them; there is one now that can be seen in use on the Pennsylvania Railroad, beyond the Market-
192 street bridge; that was built between sixteen and nineteen years ago.

TOP CHORDS.

Q. 35. Have you seen and examined Mr. Linville's description, in his patent of 1865, of the top chord composed of I-bars, set side by side, and fastened top and bottom by plates riveted with flanges to the channel or I-bars?

A. I have.

Q. 36. Have you ever seen that device used before in top chords; and, if so, when and where?

A. Humber describes such a device. I used, in 1862, a somewhat similar device: two wrought-iron I-beams, covered on top by wrought-iron plates riveted thereto, for a bridge near Mauch Chunk.

Q. 37. In what respect does the description in Humber, of this top chord, differ from that of Linville?

A. Only in this: that in Humber the chord is continuous, while in Linville the chord is in segments. The cross-sections of the two are quite identical.

Q. 38. Does that distinction in any way affect the mechanical contrivance, so far as the top chord is concerned?

A. I should say not. I would prefer the Humber device on account of its great lateral stiffness, independent of any lateral braces.

Q. 39. Do you know, then, of the use of bottom chords, such as are described in Linville's patents of 1862 and 1865, and top chords, as described in his patent of 1865, actually used or drawn and exhibited prior to the date of his patents, respectively?

A. I do. So far as the chord-bars are concerned, I have used them myself, and so far as the top chords are concerned, I have also used them myself; and I have seen a description, as I have before remarked, in Humber, of nearly an identical device for the top chord of a bridge.

Q. 40. If a round bar, with a flat and thin eye at the end, is properly defined as a wide and thin eye-bar, how would you define a square bar, with a flat and thin eye at the end?

193 A. If a round bar is properly so defined, then the square bar is a flat and thin eye bar.

Q. 41. Have you examined the drawing in the "Allgemeine Bauzeitung," referred to in Mr. Linville's testimony?

A. I have.

POSTS.

Q. 42. In that post, what are the main parts?

A. That post is essentially of a cruciform section, stiffened by angle-webs.

Q. 43. Is there any essential distinction between that post and Mr. Reeves' post as described in his patent of 1862? if so, point it out.

A. The essential difference between the two is, that one is essentially of a cruciform section, while the other is a true cylinder. Material at the centre of a column has not the value to resist strains that it has if placed at the circumference thereof, since the value of a column is as the fourth power of its greatest diameter. The column, therefore, described in the German work mentioned, of the same area of section as the Reeves column, would most likely have but about one-half, perhaps one-third the strength of the Reeves column.

Q. 44. Can that post be opened so as to allow rods to pass through the centre?

A. No, sir.

Q. 45. Was the swelling of posts in the middle, or the springing them apart for the purpose of admitting the counter-braces, a known device in 1860; if so, when had you known it used?

A. I have constructed and seen constructed, as early as 1851, a bridge with a wrought and cast iron post, swelled at the centre, opened in two parts for the passage of the diagonals: that bridge was built by S. Whipple for the Troy and Waterford Road, over the Erie Canal at West Troy, New York.

Cross-examination:

THE POSTS.

X-Q. 46. What are the advantages, if any, of a wrought-iron hollow post over a solid one?

194 A. The wrought-iron hollow post is the strongest for the same area of section.

X-Q. 47. Do you think that the making of a wrought iron hollow post is the leading feature of the invention described in the patent of Mr. Reeves of June, 1862?

A. Yes; I should judge so.

X-Q. 48. It is your opinion, then, as I understand it, that the invention as described in his patent consists in throwing the largest amount of metal possible to the periphery of the column, so as in this manner to construct a hollow post or column: am I correct?

A. Yes.

X-Q. 49. Suppose that you have on the one hand a post composed of three pieces of wrought-iron, constructed in accordance with the specifications of Mr. Reeves' patent, and on the other hand a post composed of six pieces similarly constructed, would the two columns be like or unlike each other in principle and effect?

A. They would be like each other in principle, and in effect the column composed of six pieces would be the stronger of the two, in my judgment.

X-Q. 50. Suppose, again, that you have a column composed on the one hand of two pieces of wrought iron, constructed in accordance with the specifications of Mr. Reeves' patent, and on the other hand a column composed of four pieces similarly constructed, would the two columns be like or unlike each other in principle and effect?

A. They would be like each other in principle, but in effect the column of four pieces would be the stronger of the two.

X-Q. 51. In the column as described in the letters-patent of Mr. Linville of January, 1862, do you not find the feature which you have stated in answer to cross-questions 47 and 48 to be the leading feature of the invention described in the patent of Mr. Reeves of June, 1862, to wit, throwing the largest amount of metal possible to the periphery of the column, so as in this respect to construct a hollow post or column?

195 A. No; I recognize this difference: according to the specifications of Mr. Reeves, a post might be made of two pieces, each piece semicircular in form, with the flanges extending outwardly as described in his specification. These flanges, the cross-sectional area of which, together with their rivets, would give greater value in strength to the Reeves form of construction over the Linville, and the fact that the two segments are connected together at their extreme periphery, makes them in principle different, and in effect or strength widely different. In the Linville post reliance for resistance to lateral flexure is made solely upon the distance-piece which passes through the axis of a post, a point which is in the least degree effective to resist such flexure.

X-Q. 52. Cross-question 51 repeated.

A. I do not.

X-Q. 53. In the Linville column, then, as described in his patent, you find that the metal of the parts of the post is disposed away from the periphery, and to or towards the centre of the post; is that so?

A. That is so in this sense, as I have before stated: that the only part of the device of the Linville post which is calculated to resist flexure is in the interior of the post, viz, the distance-piece, b, and the rivet or bolt j.

X-Q. 54. In the letters-patent of Mr. Linville of 1862 you find a post in which are two wrought-iron plates or bars, marked a a, do you not?

A. Yes.

X-Q. 55. And is the metal in these cases disposed towards the periphery, or at the centre of the column?

A. It is at the periphery of it.

X-Q. 56. Do you designate the post of Mr. Linville as a solid column, or a hollow one?

A. It is a hollow column.

X-Q. 57. Suppose that you have in the one case a column constructed of two pieces of wrought iron, according to the specifications of
196 Mr Linville's patent in the one case, and of four on the other hand, would the two columns be similar or dissimilar in principle and effect?

A. No; there would be no difference in principle. In effect there would be a great difference; the columns of four pieces would be the weaker of the two.

X-Q. 58. Is not the object of the attachments, both in the column patented to Linville in January, and to Mr. Reeves in June, 1862, to secure the conjoint action of the parts composing the post?

A. Yes.

X-Q. 59. In the examination of the witness, John Griffin, on the part of the complainant, he was asked the following question: "X-Q. 56. Assuming as matter of fact that the method of attachment of the parts as described in said patent (Linville's of 1862) *are* effectual and sufficient to secure the conjoint action of the parts, I will ask you to state whether you do not find in said patent the feature which you have stated in your answer to cross-question 44, as being the novel feature of the post, as described in the patent of Mr. Reeves, to wit, the throwing the largest amount of metal possible near the periphery of the column?" to which question Mr. Griffin answered "Yes." Do you agree in the opinion expressed by him, or differ from him?

A. I differ. The largest amount of metal, so far as the shaft part of the Linville column is concerned, it is true, is in the periphery of it; but, as I have stated to you before, that portion of the column which makes the attachment of the two segments is in the centre of the column, or in the inside of it, and is therefore not at its periphery.

X-Q. 60. What has the base and cap of said post of Linville to do, if anything, in securing the attachment of the two segments of the shaft of the post?

A. They unite the two segments of the shaft of the post at the base and at the top.

X-Q. 61. And are they effective?

A. Yes, they are effective.

X-Q. 62. And the metal composing them is not in the centre of the post, is it?

197 A. It is not.

X-Q. 63. Calling your attention to the letters-patent of Mr. Reeves, Figure 4, and to the post described in "Allgemeine Bauzeitung," (plate 440, Figure G, Exhibit No. 1, Linville,) will you state wherein, if at all, the two differ from each other?

A. The difference between the two is in this, that in Figure G there is represented in cross-section a cruciform column, with the angles braced; but in Figure 4 of Reeves's patent there is represented a section of a column with no interior cruciform part, the column relying for its strength

upon its outer parts or periphery entirely, it having no inner parts whatever.

X-Q. 64. Suppose that in the column of Mr. Reeves, Figure 4, there were plates interposed between the flanges and extending outwards from the centre of the column: wherein, if at all, in such case, would it differ from Figure G in the work referred to?

A. It would differ in this respect, that in the Reeves case there would be four interior pieces or plates, while in Figure G of the German work there are three.

X-Q. 65. And would this difference constitute a difference in principle, in your opinion?

A. Yes; inasmuch as one of the pieces would extend entirely across the vertical section of the column, giving it in effect greater reliability in one direction than in the other direction, as to its resistance to flexure; while, in the case of the Reeves column, if the four pieces were extended to the centre, its liability to flexure would be the same in all directions.

X-Q. Do you not find in the column described in said German work, as the prominent feature thereof, the uniting of the parts of the column so as to produce hollow spaces, thus increasing the strength of the column, and the pieces composing it being of wrought iron united by rivets through flanges?

A. Yes.

X-Q. 67. Take either form of column, as shown in the drawing attached to the letters-patent of Mr. Reeves, and, assuming that a flat bar of iron was interposed between the opposite flanges and ex-
198 tended through the column, or that two such bars were interposed, meeting in the centre, would a post or column so constructed differ in principle from that described in the letters-patent of Mr. Reeves, in your opinion?

A. It would in this degree, that all that portion of those interior bars would be less and less efficient to resist flexure as they approached towards the centre or axis of the column; while in the case of Mr. Reeves, with the interposed filling-pieces, the material of such a bar as you have described, passing outward from the depth of the section, as shown in Figure 4, would give greater and greater efficiency to resis flexure in the ratio of very nearly the fourth power of the diameter of a column; while in the other instance, as you have described, the efficiency would be lesser and lesser in the same power of a diameter.

X-Q. 68. If, then, taking either Figures 2, 3, or 4 of the drawing attached to the letters-patent of Mr. Reeves, and interposing flat bars between the flanges and extending to or towards the centre, would that, in your opinion, constitute a post differing in principle therefrom, and a post so made would not, in your opinion, be an infringement upon said patent?

A. Yes; a post so constructed would, in my opinion, be an infringement upon the patent of Mr. Reeves; but the use of the material in these plates extending towards the centre would be in a great degree wasteful.

X-Q. 69. Calling your attention again to the German work, Figure G, suppose that the pieces which are interposed between the flanges were omitted, would not the post then be identical with that shown in Figure 4 of the patent of Mr. Reeves?

A. It would.

X Q. 70. Calling your attention to the text of said German work, to wit, "perpendicular to this plate are two other plates, 0.12 metres by

12 millimetres, united by peculiarly-shaped irons with flanges, thus connected to produce in the centre of the combination hollow spaces, by reason of which the rigidity of the column is increased, while the area of the cross-section remains such as is necessary in relation to the resistance to compression," and calling your attention to the drawings already referred to in said German work, do you not find therein described the advantages of distributing the metal towards the periphery, and leaving hollow spaces in the interior of the column?

A. Yes, I do.

THE LOWER CHORDS.

X-Q. 71. Did you ever see and examine an iron bridge constructed by Mr. Linville on the Pennsylvania Railroad, west of Harrisburg, over the Pennsylvania Canal, near Susquehanna station; if so, when did you first see it?

A. I did see a bridge constructed by Mr. Linville, some few miles above Harrisburg. I saw it first when in process of erection; the date I cannot fix, except by saying that it was erected at the same time that I was erecting a bridge across the canal at Middletown.

X-Q. 72. Did you erect said bridge at Middletown prior or subsequent to the time when the drawings made by you, and referred by you in your examination-in-chief for the arsenal bridge, were submitted to Mr. Thomson?

A. The bridge at Middletown was erected subsequent to the time I submitted that drawing.

X-Q. 73. In what month of what year did you submit those drawings?

A. I cannot give you the month; but it was in the fall of 1860.

X-Q. 74. Do you know, and, if so, will you state, when the bids were opened that were submitted for the arsenal bridge?

A. I do not recollect.

X-Q. 75. Assuming that said bids were opened on the 15th of December, 1860, will you state how long prior to that date your drawings were submitted, and to whom sent or delivered?

A. My impression is that the drawings were sent to Mr. Wilson, the chief engineer of the road, and that they were out of my possession from the time that I sent them until they were returned to me by Mr. Wilson, some four to six weeks.

X-Q. 76. Are you not aware of the fact that the bridge constructed by Mr. Linville over the canal near Susquehanna station was constructed during the summer of 1860?

A. I am not aware of that fact.

X-Q. 77. Did you examine the lower chords of that bridge; and, if so, will you state how they are disposed in reference to the suspension-bars and bases of the post?

A. My recollection is that they were disposed similar to that disposition shown in the patent of Mr. Linville of January, 1862. The bars, I think, were made of hammered iron; the post, if I recollect aright, was of cast iron entire; and, so far as the footing of the post is concerned, it was very similar to a bridge that I had erected over the Delaware at Easton, and similar to the bridge that I was then erecting over the canal at Middletown.

X-Q. 78. Wherein, if at all, did the method of disposing or combining the lower chords with the bottoms of the posts, as employed in the bridge erected "over the Delaware at Easton," and "over the canal at

Middletown," differ from the method as shown in the drawing submitted by you for the arsenal bridge, and introduced in your examination-in-chief?

A. They differ only in the fact that the bridge as designed by me for the arsenal location had the eye-bars of the chord attached to the pin outside of the post; the diagonals were attached to the pin between the flanges of the post in all these cases entirely similar.

X-Q. 79. Will you please illustrate by a pencil sketch the method of disposing or combining the lower chords as employed by you in the bridge "over the Delaware at Easton and over the canal at Easton?"

A. I have the original working drawing, and I annex hereto, marked by the examiner Defendants' Exhibit Murphy, 1, a copy of said drawing as the parts embraced in the question.

X-Q. 80. In said drawing are not the lower chords all placed outside of the base of the post, and not between ribs?

A. They are so placed.

X-Q. 81. And in this respect they differ from the disposition of the lower chords as described and claimed in the letters-patent to Mr. Linville of January, 1862, do they not?

201 A. In the fact that they are located at a different point on the pin from the Linville bridge, is true; (but that in effect, and in principle, and in function, they are identical with the Linville patent of 1862, is true. The function of the lower chord of any bridge is to resist a tensile strain; to resist a tensile strain we may use a round or a square or a flat bar, or a loop bar, as in the case of the Delaware bridge. The connection with the post, the diagonal, and the chord is the vital feature of the chord device. In the case of the Delaware bridge, which was devised by me in 1858 and 1859, erected by myself and my partners, Messrs. A. & P. Roberts, I sought to gain a connection with a wrought-iron pin, upon which a post could be seated, and upon which the roadway could be placed in combination with the diagonal and the chord, such as would insure greater security against fracture or breaking of the pin, as it has hitherto been made of cast iron. This bridge across the Delaware was erected in place under my direction in the fall of 1859, sometime between the first day of August and first day of November, in pursuance of a contract made with Piper & Shiffler.)

(That part of the foregoing answer included within parentheses objected to by counsel for the Keystone Bridge Company, as being irresponsive to the question, and argumentative.)

X-Q. 82, and cross-question 81 repeated.

A. In the disposition upon the pin, so far as the chord connection with the pin, with the diagonal and with the post, they are in principle, in effect, and in function the same.

X-Q. 83. In the Linville bridge (patent of 1862) are not the lower chords disposed at short intervals on the connecting-pin, and partly between ribs of the bases of the posts, and partly outside of the bases of the posts, two strands of the lower chords being disposed, one at either side of each suspension bar, and partly between the suspension bars; and, on the contrary, in your drawing are not all the chords placed outside of the base of post and all outside of the suspension diagonals? You are asked as to the fact, and not as to the effect.

202 A. In my plan of the bridge at the Delaware the chords are all placed on the pin outside the post. In the Linville plan they are partially placed outside the post, and partially between the ribs inside. What you mean by short intervals between the chords—it being a relative question—I do not comprehend. An interval between chords

might be called short if it were 3, 10, 20, 30 inches. The chord acting by tension only, the interval, to be the most effective, would be when the eye-bars were the closest together, as is the case in both Mr. Linville's and mine.

X-Q. 84. In your drawing, what is the interval or clear distance between two inner chords?

A. In the bridge at the Delaware there are in effect two chords to each line of posts; the individual members of those chords are placed close together, except at the third panel, at which point there is a space between them of about two inches.

X-Q. 85. Cross-question 84 repeated.

A. The distance is twelve inches, and that space is occupied by the diagonals, which are the supporting members of the bridge against vertical pressure and the ribs of the foot of the post.

X-Q. 86. In the Linville plan (patent of 1862) about what is the distance between the two adjacent strands or chords?

A. I suppose the chords would be four inches apart.

X-Q. 87. What effect is produced on the lower chords of bridge-trusses by the action of suspension diagonals transmitted to the chord by means of the connecting-pin?

A. The action of the suspension diagonal upon the pin produces entirely a transverse strain upon the pin, inducing a tensile strain directly upon the lower chords, and only a direct line tensile strain upon the lower chord.

X-Q. 88. If the diagonals produce, as you say, a transverse strain on the pin, and if the effect of the diagonals is resisted in the horizontal direction by the opposite tensile strain on the lower chord, will the tendency of the pin to bend or break be increased or diminished as the distance between two adjacent lines or strands, one of either side of the tension diagonals, is increased or diminished?

203 A. The tendency of the pin to bend will be inversely as the distance between the diagonal and its fellow-chord. In Mr. Linville's plan the distance between the diagonal and its fellow-chord is very nearly the same as is the case in the Delaware bridge. The distance apart of the lines of chords has no effect as to the transverse strain upon the pin per se; the transverse strain is as the distance apart inversely of the dalgonal and its fellow-chord.

X-Q. 89. The tendency of a suspension diagonal is to produce or cause a transverse strain upon the pin, is it not?

A. Yes; it is.

X-Q. 90. And this is opposed by the lower chords, is it not?

A. It is in part by the lower chord, and part by the post.

X-Q. 91. And will this resistance to the transverse strain on the pin, caused by the suspension diagonal offered by the lower chords, be greater or less, according as the lower chords are spread away from the diagonal on the pin?

A. The transverse strain upon the pin will be the greater as the lower chords are removed from the diagonal upon the pin.

X-Q. 92. Applying this principle to the Linville bridge, (patent of 1862,) will you state whether the tendency of the pin to bend or break, produced by transverse strains of the suspension-bars, would be the same if the lower chords were transposed from the inside of the base of the post to the outside, leaving a long unsupported distance on the pin between the two suspension diagonals, instead of being disposed partly between and partly outside of the suspension-bars, as shown in the patent?

A. In the Linville patent, if the roadway was not placed upon the lower chord eye-bars, the lower chords might as well be placed outside of the post as inside; as they are situated, it becomes a partial necessity to place the chord-bars within the post. In the Linville patent the transverse strain upon the pin is greater on account of the situation of the roadway upon the eye-bars.

X-Q. 93. You have not answered my question, and are asked again, whether the transverse strain produced upon the pin by the sus-
204 pension diagonals would be resisted to a greater extent, or to a less extent, by the lower chords, if they (the lower chords) were transposed from the inside of the base of the post, as shown in the patent of Linville, to the outside of the base?

A. No; it would make no difference, since, so far as the transverse strain upon the pin is concerned, due to the diagonal, it is inversely as the distance of the diagonal from the chord. So far as the internal chord is concerned in relation to the diagonal, they produce no strain transversely upon the pin greater than the external chords do, judging from the drawing of the Linville patent that I have before me, except that extra strain transversely upon the pin which is due to the roadway beams being placed upon the chord.

X-Q. 94. In the combination, as shown in Linville's patent, are not the strains upon the pin distributed throughout the entire length of the pin?

A. Yes.

X-Q. 95. And would the strains upon the pin be thus distributed in any other combination of the several parts?

A. Yes.

X-Q. 96. State how, or by what other combination of the parts in that bridge, the strain upon the pins would be thus equally distributed.

A. Suppose that in Linville's patent he had placed the chord eye-bars outside of the post, and had placed this roadway upon them, as he has now placed it, and had given such strength to the foot of his post as would have equally distributed the bearing of the post upon the pin, and had disposed his diagonals closely to his eye-bars, then the strain upon the pin would have been equally distributed.

X-Q. 97. If a pin be supported at two points, and a weight be applied on the pin midway between the supports, will not the transverse strain on the pin increase directly as the distance between the supports?

A. Yes.

X-Q. 98. Calling your attention to answer to question 34 of
205 your examination-in-chief, will you state whether the bars therein referred to were eye-bars, and will you describe the combination in which they exist in the bridge referred to?

A. The chords of that bridge are continuous flat bars, with a block seated upon them at each panel, through which passes a vertical rod attached underneath the chord. Upon the block is seated the diagonal of the main and counter diagonal of the bridge: the roadway beams are placed upon the chord, as in Mr. Linville's patent of 1862.

X-Q. 99. The chords, then, are not eye-bars in that bridge?

A. No.

X-Q. 100. And the posts: how about them?

A. There are no posts; it is what is usually called the Howe plan of construction: a rod is employed in the place of a post, the diagonal acting by a thrust.

X-Q. 101. Then, in said bridge there is not found a series of wide,

thin eye-bars disposed between ribs on the bottom of posts, and combined as in the patent of Mr. Linville; is that so?

A. There is not a series of wide and thin eye-bars in this bridge, but there is a series of wide and thin bars without eyes; and it differs in its construction from Mr. Linville's only so far as the ends of the bar is concerned; in that the bar has no eye or pin attachment, and is similar to Mr. Linville's—in having the roadway placed upon wide and thin bars.

X-Q. 102. In other words, it differs from Mr. Linville's in these particulars: that in that bridge there are no eye-bars; that there are no posts; that there are no bases to posts with ribs, and no pins passing through eye-bars, and through the bases of the posts, and through suspension diagonals; is that so?

A. It differs from Mr. Linville's in all the points you have named.

TOP CHORDS.

X-Q. 103. In the patent of Linville of 1865 the upper chords are made in short sections of one panel in length, are they not?

A. Yes.

206 X-Q. 104. In the upper chords, referred to as having been made by you, this was not the case, was it?

A. It was the case with the exception that the plate or top of the I-beams, which were the essential parts, the plate was carried across the joint and made continuous.

X-Q. 105. Were the upper chords so used by you made to resist transverse strains?

A. They were not, except such transverse strains as are induced by compression.

X-Q. 106. That strain that you have referred to is one common to all beams under compression, is it not?

A. Yes.

X-Q. 107. In reference to Humber's work, the chord is shown to be riveted to a continuous plate-iron web, which forms the side of the bridge, is it not?

A. Yes.

X-Q. 108. And in this respect it differs from that described in the patent of 1865 of Linville, does it not?

A. So far as those parts have vertical and diagonal functions, the two constructions are entirely different; but, so far as the upper chord of the two constructions are concerned, both performing the same function in the bridge, they are quite identical.

X-Q. 109. In the Humber bridge does the upper chord resist any other than compression strain?

A. It might resist a transverse strain as well as in the Linville construction. A roadway could be placed upon the Humber construction in the same manner as the Linville construction, and the Humber construction would resist transverse strains as well.

X-Q. 110. I will ask you whether there is not this difference in the upper chords, as described in Humber's work, and those described and claimed in Linville's patent of 1865, to wit, that in Humber the chord is so constructed as to constitute a continuous chord; whereas in Linville's patent they are made of a series of short tubes or cells, abutting together on each post?

207 A. I cannot judge from the sectional view given in Humber whether there is the difference between the two that you name so far as the top chord is concerned.

THE POSTS.

X-Q. 111. When was Mr. Reeves' post, as patented June 18th, 1862, first employed by him in any bridge or other structure?

A. I do not remember when or where it was first used.

X-Q. 112. Calling your attention to your answer to question 45 in chief, in which you say "I have constructed and seen constructed a bridge with a wrought and cast iron post, swelled at the centre, opened in two parts for the passage of the diagonals," &c., I will ask you whether the body of that post was not composed of two pieces of cast iron, each piece being one-half the length of the post, very similar to your exhibit "Defendants' Exhibit Murphy?"

A. Yes.

X-Q. 113. And the wrought-iron part of said post was simply rods of wrought iron used to truss the post: is not that the case?

A. Yes.

X-Q. 114. Then there are these differences between said posts and Linville's, patented January 1862, to wit, that in the one the post was of two pieces of cast iron, the one set upon the other, at equal distance from the two ends; the other, Linville's, is not made of cast iron, but is made of wrought iron, and the pieces composing it are the entire length of the post?

A. That is true.

Re examination:

Q. 115. Referring you to the fifty-ninth cross-interrogatory, and your answer thereto, have you prepared a drawing to illustrate the distinction there referred to, and have you anything to add on the subject?

A. I have prepared such a drawing, and now produce it, marked "Murphy, No. 5, June 15th, 1870." Figure 1 represents a section of Reeves' post of as large a number of segments as could be con-
208 veniently drawn, intended to be illustrative of its increase of strength by the increase of the number of parts of a column. Figure 4 represents an elevation of the same column. Figure 2 represents a section of the Linville post, intending to illustrate it where its parts are increased as greatly as possible, as in the case of the Reeves. A represents, in Figures 2 and 3, the distance-piece. B and B represent the main periphery parts of the column attached by the rivets L to the distance-piece. It will be seen that, in the case of the Reeves post, the outside flanges at all points are closely riveted together. In the case of the Linville post, the outside parts have spaces between them, increasing from the end towards the centre. To explain the difference between these two posts, in a somewhat technical and scientific way, we may say that in the case of all structural forms material must be used in the direction of not less than three lines or forces. In the case of a column—in fact, of any column—material must be found in the direction, first, of a vertical line; secondly, in the direction of a horizontal line; thirdly, in the direction of a diagonal line. It will be seen, by an examination of the drawings referred to, that the Reeves post, by its parts C and D, fulfill the vertical value; and that, by the rivets uniting these two parts closely together, it also fulfills the diagonal and horizontal value. In the case of the Linville column, if we examine the elevation, Figure 3, we will see that, while the vertical value is sustained by the parts B B, and the horizontal value sustained by the inside part A and its rivets L L, there is left a force still unprovided for in the direction of the line M M, (Figure 3,) called the diagonal value of

the column. Satisfaction to this force, it will be plain to see, can only be accomplished by the firm union of the parts of the peripheries of the Linville column, viz, B B.

JOHN W. MURPHY.

Sworn and subscribed before me this 15th day of June, 1870.

JOHN RODGERS,
Examiner.

209 JUNE 15TH, 1870.

Present: R. C. McMurtrie, for the complainants; C. B. Collier, esq., for defendants.

WILLIAM GEORGE, a witness for the complainant, being duly sworn, saith:

I am fifty years of age; at present my occupation is that of a draughtsman.

Question 1. Have you any special experience and knowledge on the subject of rolls used in rolling-mills? and, if so, state such facts as will enable the court to understand what has been your experience and knowledge on the subject.

Answer. I have been engaged, since 1844, in the capacity of roll-turner and designer of rolls, and as superintendent of machine-shops for getting up rolls and rolling-mill machinery. I have been engaged with the Montour Iron Company, the Phœnix Iron Company, the Tennessee Iron Works, in southern Kentucky, and the Bethlehem Iron Works, Pennsylvania, and am at present with James Moore, at Bush Hill Iron Works, where I made all the drawings for the rail-mill of the Reading Railroad Company, also for the rail-mill of the Pennsylvania Steel Company at Harrisburg.

Q. 2. Look at Exhibits H and I, and state what would be the cost of a set of rolls required to make an iron post, if it was made by the plan as shown in Exhibit H, of two half-circle or semipolygonal pieces.

A. I have no hesitation in saying that there is no rolling-mill in the United States that would undertake to make semicircular or semipolygonal columns of the diameter as that mentioned in this exhibit. I would say, from my experience, it would take rolls of not less than forty inches in diameter, the cost of which would be as the difference of the square of forty to the square of from eighteen to twenty-one, which is about the average size of our mills; and that all appliances appertaining to the working would bear about the same relation to the cost.

Q. 3. If such a column were made in sections, as shown in Ex-
210 hibit I, how would that cost compare, in preparation and manufacture, with the cost of ordinary large-sized beams that are now accustomed to be made at the mills?

A. The segment, as shown in Exhibit I, could be made on any ordinary eighteen-inch bar-mill, such as the Phœnix Iron Company's present mill, which is nineteen inches; the Abbott Iron Company, which is twenty-one inches; the Bethlehem Iron Company, which is twenty-one inches; the A. & P. Roberts Pencoyd Iron Works; also Nathan Rowland's, Verree & Mitchell's, and, in fact, the average of regular merchant mills who work for the trade.

Q. 4. What is the limit of the present mills of first class for making columns in sections as shown in Exhibits H and I?

A. In Exhibit H, I would say that a ten-inch column, if composed of two pieces, would be about as large as could be rolled in any mill that

I know of that is used for bar or rail purposes or beams. There is no limit to the size at which the other could be made. Upon the plan of Exhibit I they might go to thirty feet.

Q. 5. If a mill were constructed capable of rolling sections of columns as in Exhibit H, would such a mill be fit for the ordinary uses of a mill besides?

A. It certainly would not be practicable to use such a mill for the ordinary run of iron in the trade—that is, such as bar iron or rails.

WILLIAM GEORGE.

Sworn and subscribed to before me this 15th day of June, 1870.

JOHN RODGERS,
Examiner.

AUGUST 31ST, 1870.

Present: R. C. McMurtrie, C. B. Collier.

JOHN GRIFFEN, being recalled, says:

Question 1. Were you present at the testing of two columns,
211 one made according to the specifications in Mr. Reeves' patent, and the other made according to the specifications in Mr. Linville's patent of 1865?

Answer. I was.

Q. 2. State when and where those trials were, and what were the results.

A. One of the trials was made in the upper Keystone Bridge Works, at Pittsburg, on Thursday, June 23d, 1870; the other was made at Phœnixville, Chester County, on the 25th June, 1870. One Keystone and one Phœnix column was tried at each place. The following are the results of the trial—first, as matter of fact, and, secondly, my deductions, as an expert, from those facts:

Comparison of trials of the Keystone and Phœnix columns—one at Pittsburg on the 23d June, and the other at Phœnixville on the 25th June.

One Keystone and one Phœnix column tried at each place. They were intended to be all of about the same sectional area and length; but, while they were all of the same length, the Keystone columns proved to be much larger than the Phœnix, as shown by the measurement of the pieces and by the relative weights. The columns tested at Phœnixville weighed as follows: Keystone, 960 pounds; Phœnix, 858 pounds; difference, 182 pounds, or about 12 per cent. All the posts were tested with rounded ends, being fitted with cast-iron hemispherical pieces, slightly flattened, having a depth of about four inches in the line of the axis, thus adding eight inches to their length, making the total length eighteen feet eight inches. Their position while under trial was horizontal. At Phœnixville the two posts were supported at their middle by counter-weights equal to half the weights of the posts. This was done for the purpose of neutralizing the strain due to the weight of the material acting downwards, and to enable it to move freely in its weakest direction when subjected to the pressure of the machine. At Pittsburg this precaution was omitted; in other respects there was no
212 material difference in the mode of testing at the two places. At both places the trials were made by means of a hydrostatic press, each press containing an area of 260 square inches in the plunger. In

the trial at Phœnixville no attempt was made to ascertain the diminution of length and amount of set under increasing pressures, but only to determine the actual crippling load, this being the primary object of the experiment.

Pittsburg trial.

Keystone column—crippling load	455,000 lbs.
Phœnix " " "	481,000 "
Difference in favor of Phœnix	26,000 "

Trial at Phœnixville.

Keystone column—crippling load	448,500 lbs.
Phœnix " " "	435,500 "
Difference in favor of Keystone	13,000 "

Average of trials.

Keystone column—crippling load	451,750 lbs.
Phœnix " " "	458,250 "
Difference in favor of Phœnix	6,500 "

Areas and weights compared.

Keystone	$\frac{960 \text{ lbs.}}{18 \text{ ft.} \times 30\frac{1}{4} \text{ lbs. per ft.}} = 16$	sq. in. by w'g't gr's;	$\frac{905.5 \text{ lbs.}}{18 \times 3\frac{1}{4} \text{ lbs.}} = 15.09$	sq. in. by w'g't of s'g'ts.
Phœnix,	$\frac{858 \text{ lbs.}}{18 \text{ ft.} \times 3\frac{1}{4} \text{ lbs. per ft.}} = 14.3$	" " "	$\frac{842.5 \text{ lbs.}}{18 \times 3\frac{1}{4} \text{ lbs.}} = 14.04$	" " " "
Differences,	1.7	" " "	1.05	" " " "

Effective weight and dead weight compared.

Keystone,	gross w'g't,	960 lbs.;	w'g't of 4 seg'ts,	905.5 lbs.;	dead w'g't,	54.5 lbs.	= 3.028	per f't.
Phœnix,	" "	858 "	" " 4 "	842.5 "	" "	15.5 "	= 0.861	"
Differences,		102 "		63 "		39 "	= 2.167	"

213 Economic values compared per square inch of available section.

Keystone—average,	$\frac{451,750 \text{ lbs.}}{15.09 \text{ sq. inches}} = 29,937$	lbs. per square inch.
Phœnix "	$\frac{458,250 \text{ lbs.}}{14.04 \text{ sq. inches}} = 32,639$	" " " "
Difference favor of Phœnix,	2,702	" equal to 9 per cent.

Economic values compared by the weight gross.

Keystone—by gross wgt. = 16 sq. in. of section,	$\frac{451,750 \text{ lbs.}}{16} = 28,234$	lbs. per sq. in.		
Phœnix " " 14.3 " "	$\frac{458,250 \text{ lbs.}}{14.3} = 32,045$	" " " "		

Favor of Phœnix per square inch, 3,811 lbs. = 13½ per cent.

Or, in other words, 100 lbs. of iron in the Phœnix column is of the same value as 113½ lbs. in the Keystone.

PARTICULARS ABOUT THE SHAPE AND STYLE OF COLUMNS.

The Keystone is composed of four segments, with flanges on their edges; so that when placed together they form the usual octagonal columns swelled at the middle, made at the Keystone Iron Works. These segments are three-eighths inch full. The opening between the flanges at the middle is one and five-eighths inches; length of ferrules at middle same, viz., one and five-eighths inches; rivet-shank between flanges same, viz., one and five-eighths inches; riveted up at flanges, four inches from centre to centre. Length of wrought-iron portion, eighteen feet; including cast-iron rounded ends, eighteen feet eight inches. The Phœnix is composed of four segments, circular form, with flanges; close-riveted at flanges, six inches from centre to centre of rivets, except three rivets at each end, which were three inches apart; thickness of metal, scant three-eighths; external diameter of barrel, eight inches; length, same as Keystone. The experiments, I think, fully prove that swelling the posts in the middle and riveting up the flanges by the interposition of lengthened rivet-shanks and ferrules, diminishes their
214 power of resisting vertical strains; *i. e.*, strains in the line of the axis of the post. It also increases the dead weight of metal by the whole weight of the rivet-shanks and ferrules between the flanges. Close riveting makes the pieces comprising the Phœnix column an entire and absolute unit; while the segments of the swelled Keystone column, being separated from each other, act in a measure as independent pieces. This defect in the latter form increases in intensity in proportion to the amount of separation.

(Annexed hereto is a sectional drawing taken from the segment of each post tried at Phœnixville.)

SEPTEMBER 8TH, 1870.

Present: Mr. McMurtrie, Mr. Collier.

ADOLPHUS BONZANO, a witness on the part of the complainant, being duly affirmed, saith:

Question 1. What is your age and occupation?

Answer. I am thirty-nine years of age, and am a civil and mechanical engineer.

Q. 2. Where were you educated, and of what country were you a native?

A. I was educated in Germany. I am a native of the kingdom of Wurtemburg. I left Germany in 1850. I am as familiar with the German language as that of the English.

Q. 3. Referring you to the "Allgemeine Bauzeitung," (the same paper of which a translation was made by Mr. Linville,) please translate that passage accurately into English.

A. These iron columns, a section of which is on Plate 440, Figure 5, marked K and G, consist of one flat iron bar of three-tenths metre, by twelve millimetres strength, which form the main part of the column, and with which two other irons of twelve metres width by twelve
215 millimetres thickness, perpendicularly connected by means of peculiar-formed angle-iron, so that in the centre of the connection a hollow space is made, by which the carrying moment of the column is increased, while the section remains which is necessary for carrying the load.

Q. 4. Look at the translation of that passage, (Linville's testimony, answer to question 12, page 68,) and state whether there is anything in

that translation which is so incorrect as to convey an improper impression of the meaning of the original; and, if so, what is it?

(Objected to by counsel for Keystone Bridge Company, as being argumentative, leading, and assuming that which has not been proved.)

A. The translation says, "Perpendicular to this plate are two plates, twelve metres by twelve millimetres, united by means of peculiarly-shaped irons with flanges." These words "peculiarly-shaped irons with flanges" are called in the German work "peculiar-shaped angle-iron;" no flanges are mentioned.

Q. 5. Are there any words in that text which point to an advantage existing in that form of post by the distribution of the metal of the post towards the periphery?

(Objected to by Mr. Collier as leading.)

A. No such advantage as distributing the metal towards the periphery of the column is described or followed in practice in the making of this column.

(Concluding portion of the answer objected to as being irresponsive to the question and argumentative.)

Q. 6. Are you familiar with Mr. Reeves' patent of June 17th, 1862, and with the post constructed according to that patent?

A. I am familiar with Reeves' column. I have constructed bridges in which I have used over 2,000,000 pounds of that column.

Q. 7. Suppose that in Mr. Reeves' column, Figure 4 on drawing annexed to the patent, there were plates interposed between the flanges and extending outwards from the centre of the column, wherein, if at all, in such case, would it differ from G in the German work just referred to?

216 A. The filling-pieces in Mr. Reeves' column are not the principal parts as they are described in the German work. They are only incidental. The column is complete without them. Not so with the other column. But made as you have stated it would differ in principle from Figure G in the German work. In the latter the plates are described as the principal part—the core, the kernel of the column, while the angle-irons, which are attached to the principal part, are used to hold it together, of course adding to its strength. In the Reeves column this is just the reverse. The segments are the principal parts. The filling-pieces are only auxiliaries, and not at all essential to make a complete column; and if filling-pieces were extending from the centre outwards to the periphery it would be a waste of iron badly placed, adding but very little to its strength. The principle in the Reeves column are the segments with flanges and the mode of combining them. If filling-pieces are used in the Reeves column, it is not done for the purpose of making a perfect column, but only as a convenience for making attachments or for increasing the sectional area, and then these filling-pieces are not placed between the flanges of the segments; that their section lies in the periphery of the segments as near as possible. One pound of iron to resist flexure in a Reeves column of say thirty diameters' length is worth as much as four pounds of iron in filling-pieces placed at half the distance from the centre and the periphery. Hence, the periphery is where the metal of a column ought to be placed, unless there are special reasons for sacrificing iron in strength for convenience.

Q. 8. Do you find in the column described in said German work, as a prominent feature thereof, the uniting the parts of the column so as to produce hollow spaces, thus increasing the strength of the column, and that the pieces composing it being of wrought iron united by rivets through flanges?

A. Yes. But such a combination of a flat bar and angle-iron to produce hollow spaces is nothing new. Engineering works are full of such illustrations. In Stevenson's tubular bridge the top and bottom chords are made up of such combinations.

217 (So much of the preceding answer as follows the word "yes" objected to, as being irresponsive and argumentative.)

Q. 9. Take either form of the column, as shown in the drawings attached to the letters-patent of Mr. Reeves, and assuming that a flat bar of iron was interposed between the opposite flanges and extending through the column, or that two such bars were interposed meeting in the centre, would a post or column so constructed differ in principle from that described in the letters-patent of Mr. Reeves, in your opinion?

A. It would be a Reeves column, but the iron would be very wastefully placed. If the interposed flat bars had been so made and used as to manifestly constitute the main or principal part of the column, and the segments so small as manifestly intended to be only used as to hold the flat bars in position, then it would not be a Reeves column, and would differ in principle. Such a post would neither be strong or economical. In the Reeves post, on the contrary, the iron, or nearly all of it, is disposed in the segments; and if filling-pieces are used for convenience of attachment or increasing sectional area, they form but a very small part of the sectional area of the column, and are in the post between the flanges at a maximum distance from the centre; they are, so to say, a thickening of the flanges—the construction of the whole showing conclusively that its strength, stiffness, and economy depends on the distribution of the iron around the periphery and exterior flanges, and not on interposed flat bars running towards the centre, where it is known to be the least effective for resisting flexure.

Q. 10. Calling your attention to the text of the German work of which you have given a translation, do you find described therein the advantages of distributing the metal towards the periphery and the leaving hollow spaces in the interior of the column?

A. The advantages of the hollow spaces are mentioned. The advantages of the distribution of the metal towards the periphery is not described or mentioned. If the advantages of distributing the

218 metal around the periphery had been intended, there should have been no flat bars at all, especially at the centre; but the described angle-irons should have been expanded and have become, as in the Reeves column, the main part. In fact, it is not possible, with angle-irons so placed as in the column in the German work described, to distribute metal towards the periphery.

(So much of the foregoing answer as follows the word "mentioned," at the end of the first paragraph, objected to by counsel for the Keystone Bridge Company as being argumentative.)

Q. 11. What is the difference of the post, as described in that German work, and the ordinary cruciform post, for the purposes of practical utility?

A. I consider the post described in the German work simply a cruciform post, very much like that which has been in use a very long time; the only difference being that the angle pieces which hold the main part together have their corners cut off, by which hollow spaces are formed about the centre. The strength of such a post is very little greater to resist flexure than those made in the cruciform way, because its stiffness depends only on the flat bars; the angle pieces do not become strained transversely until the external fibres of the flat bars have

failed; then the angle-bars will be useless. This is the case with all cruciform posts; the metal around the center is of very little use to resist flexure; they are made in violation of the well-known law, that the resistance to flexure is directly in proportion to the squares of diameters of posts, or in proportion to the square of the distance the metal is placed from the centre.

Q. 12. What is your experience of the utility of the Reeves post, and how does it compare with cruciform posts and all other posts which were known up to the date of its introduction, and including the forms suggested in the said German work?

(Objected to, as the ground for such question has not been laid by the counsel examining the witness.)

A. I consider the Reeves column the best, the most economical-shaped column, and the most convenient for making attachments with parts of bridges, viaducts, and other iron structures in which said columns
219 can be used. I have made comparisons of relative cost of different posts, and for upper chords in the interior posts for bridges and inclined struts for viaducts, and have found those columns more economical than any other. If I had not the use of this column in constructing iron structures I would not like to compete with one who had the use of it.

Q. 13. Were you present at the test of the Keystone and Phœnix column made at Phœnixville on the 25th June last?

A. I was.

Q. 14. Look at the statement of Mr. Griffen, (answer to question 2,) and say whether or not that is correct, and in what particulars incorrect, if at all.

A. I have examined the testimony of Mr. Griffen, of the test of the Keystone and Reeves columns on the 25th June last at Phœnixville, and find his tables and deductions therefrom correct.

Q. 15. Look at the drawing herewith produced, marked "Bonzano, No. 1," and state what it represents.

A. I have examined it, representing columns made as described in the German "Allgemeine Bauzeitung," and also Reeves' column. I have compared a sectional area of each with the other, and find them as nearly equal as possible. I see, at a glance, the unequal distribution of the metal in the column described in the German work, the metal being nearly all placed at a small distance from the centre, the iron in the Reeves column being all distributed at the periphery, its strength being more than three times as great; their respective area equal.

SEPTEMBER 12TH, 1870.

Present: Mr. McMurtrie, Mr. Collier.

Cross-examination of Mr. Bonzano:

Cross-question 16. Are you engaged at this time in the construction of iron bridges; if so, by whom are you engaged?

Answer. I am a partner of the firm of Kellogg, Clark & Co.,
220 and I act as engineer, designer, calculator, and constructor. That firm is engaged in the construction of iron bridges.

X Q. 17. From whom does said firm obtain its iron?

A. At present the firm obtains all its material from the Phœnix Iron Company.

X Q. 18. For how long have you been thus engaged as engineer, designer, &c., for that firm?

A. I have been in the firm of Kellogg, Clark & Co., engaged in that capacity, for the past ten years and a half.

X-Q. 19. During that period of time has said firm obtained all its iron from the Phœnix Iron Company?

A. Yes.

X-Q. 20. Prior to that time were you engaged in designing and engineering bridges; if so, where, and on what kind of bridges were you so engaged?

A. I have been engaged since 1858 in constructing and designing of iron bridges for the firm of Kellogg & Co.; and the Detroit Bridge and Iron Works, at Detroit, Michigan. We have built the Bollman truss, Fink truss, and the Whipple, or Pratt, truss.

X-Q. 21. What is understood by the term "angle-iron" as employed in reference to bridge structures?

A. Angle-iron I would call two flat bars of iron meeting at one edge, being a unit at that point, and connected with different parts of bridges for a particular purpose.

X-Q. 22. Is the angle at the point of union of the two pieces of an "angle-iron" a right angle, or greater or less than a right angle?

A. It can be a right angle, a greater, an obtuse, or an acute angle, but is generally made to form a right angle, for the convenience of making attachments.

X-Q. 23. Will you now state wherein an angle-iron differs, if at all, from flanged iron, or an iron bar with flanges?

A. An angle-iron has nothing but flanges; flanged iron, by its very terms, means a body of iron with flanges attached.

221 X-Q. 24. Calling your attention to the drawings in "Allgemeine Bauzeitung," Plate 440, sections F, G, H, and K, will you state whether the sections forming the peripheries of the columns therein represented are not what is known as "flanged iron," or bars of iron having flanges upon their edge?

A. I would not call those described angle-irons flanged iron. I consider them nothing more than angle-irons with one corner cut off.

X-Q. 25. You have said, in answer to cross-question 25, that "an angle-iron" has nothing but flanges. Have the sections shown in said plate nothing but angles?

A. The corner being cut off on that angle-iron, makes or forms an additional surface, or an additional angle.

X-Q. 26. In said drawings are not the sections forming the peripheries properly described as being flat bars, with flanges upon their edges?

A. What you call a "flat bar" is formed by having the corner cut off of an angle-iron, and still nothing but flanges remain.

X-Q. 27. Then you desire to be understood as giving your testimony finally, that the peripheries of the columns, as shown in said work, are not formed of flat bars of rolled iron, intervening between flanges on their edges respectively.

A. The peripheries of the column are the flat bars which go through the centre of the column, angle-iron connecting them.

X-Q. 28. Calling your attention to section marked G in said German work, on the one hand, and to Figure 4 in the drawing attached to the letters-patent of Mr. Reeves on the other hand, and upon the supposition that the filling-pieces, as interposed between the flanges in section marked G, were removed therefrom, will you state wherein, after such removal, section G would differ, if at all, from Figure 4, Reeves' patent?

A. If those interposed plates in Figure G of German work were removed they would form nearly a cruciform-shaped post, and differ from the Reeves column, Figure 4, in that respect. The iron in Figure G

would not be as near the periphery of the column as it is in the Reeves column.

222 X-Q. 29. Upon the same hypothesis would the two posts, G and Figure 4, respectively, be similar or dissimilar in principle, in your opinion?

A. They would be dissimilar in principle and effect.

X-Q. 30. In the cross-examination of the witness John W. Murphy he was asked this question: "X-Q. 69. Calling your attention again to the German work, Figure G, suppose that the pieces which are interposed between the flanges were omitted, would not the post then be identical with that shown in Figure 4 of the patent of Mr. Reeves?" To which he answered: "It would." Do you agree in the opinion as therein expressed by Mr. Murphy, or do you differ from him?

A. I differ.

X-Q. 31. Do you understand that the posts and the flanges, as shown in the sections of the columns of the German work—that is, the flat bars with the flanges on their edges—are formed in those shapes by being so rolled?

A. It appears that these angle-irons are so rolled; but I cannot perceive that they are so made as to form a flat bar with flanges.

X-Q. 32. Are you able, from your present knowledge of the forms of posts, as shown in Figure 4, Reeves' patent, and sections F, G, H, and K of the German work, and without having either the patent or the plates present before you, to make drawings in section of the same respectively; if so, will you please now make such drawings, omitting the interposed flat bars?

A. I can do so, and do now herewith produce a drawing, marked "Bonzano, cross-examination, A," representing a column, as described in the German work, leaving out the flat bars interposed between the flanges and entering the angle-irons.

X-Q. 33. Does the drawing thus made by you represent columns of equal or unequal diameters?

A. They represent columns of unequal diameters, but equal area, as near as I could make it in this sketch.

X-Q. 34. In the construction of columns by the Phœnix Iron
223 Works, according to the letters-patent of Mr. Reeves, what is the width of the flanges?

A. The width of the flanges is about one-third of the length of the bar between the two flanges.

X-Q. 35. What is the smallest-sized post that is constructed by the Phœnix Iron Company according to Mr. Reeves' patent?

A. The smallest-sized post is a four-segment column, of four inches outside diameter, with flanges of about one inch and three-eighths in length.

X-Q. 36. Calling your attention to drawing produced by you in your examination-in-chief, (Bonzano, No. 1,) will you state the diameters of the Reeves columns represented there, marked Figures U and W, respectively?

A. Figure U represents a six-segment column, of eleven and three-fourths inches external diameter, not including the flanges. Figure W represents a four-segment column, of seven and three-quarter inches outside diameter, not including flanges.

X-Q. 37. What is the diameter of the post marked K and G, respectively, on said drawing, measured in the same manner as you have measured the Reeves columns therein?

A. I cannot measure the columns K or G in the same manner as the

Reeves column. In measuring the Reeves column, I took as the diameter of the column nearly the neutral line of the section. If I measure columns K and G across the flat bars, I do not give its diameter with reference to the columns U and W.

X-Q. 38. Give the diameter of the columns K and G on said drawing, measured to the exterior of the flat bars uniting the two flanges; that is, from 1 to 2, respectively.

A. Measuring in drawing K from 1 to 2, I find the distance to be two and thirteen-sixteenths inches; measuring on drawing G, from Figure 2 to 2, I find the distance two inches and five-eighths of an inch.

X-Q. 39. Will you now please make a drawing, to be attached as an exhibit hereto, of a Reeves column composed of pieces, as shown in Figure 4 of his patent, of the diameter of the post K, as shown in the drawing referred to?

224 A. The drawing which I have here made and produced, marked "Bonzano, Exhibit B," is a four-segment Reeves column, made in the right proportion of the flanges with the segments, and of an external diameter of the column measured at Figures 1 and 2, drawing K.

X-Q. 40. Will you now please make a drawing according to Figure 4 of Reeves' patent with the same external diameter as Figure G in your exhibit, and with filling pieces of the same dimensions and character as in G?

A. I cannot do that. If I would make the column in such a manner it would not be according to the proportion of the flange segments of the Reeves column.

X-Q. 41. Will you please make a drawing according to Figure 4 of Reeves' patent, with the same external diameter as Figure G of your exhibit, measured from 1 to 2, and with filling-pieces of the same thickness as in G, and extending outward from the centre and terminating at the edge or the flanges?

A. I cannot do that. It would be altogether out of proportion.

X-Q. 42. What would be out of proportion?

A. The flanged segments of the Reeves column; they would become angle-irons.

X-Q. 43. How would they become angle-irons?

A. The segmental part would become so small that the flanges of the segments would nearly become a unit with one another.

X-Q. 44. What is the width of the flanges as provided in the letters-patent of Mr. Reeves?

A. The width of the flanges is about one-third of the length of the segmental part.

X-Q. 45. Have you ever read the patent?

A. I have not read it fully. I know the principal, leading features of the claims of said patent.

X-Q. 46. What do you understand to be "the leading features of the claims of said patent?"

A. The principal, leading features of Mr. Reeves' patent and columns are, making a hollow wrought-iron column, with three or more
225 segments with flanges, uniting them together by rivets or bolts at the exterior part of the body, to make a unit of the different segments.

X-Q. 47. What do you find, if anything, in said letters-patent now exhibited to you regulating or prescribing the width of the flanges?

A. The flanges of the segments here exhibited are evidently made

only for uniting the segments together, and are in proportion to the length of the segment.

X-Q. 48. Suppose the flanges on the segments are increased or diminished in width, will the principle or characteristic feature of the post, as patented by Mr. Reeves, be affected?

A. If the flanges of the segments of the Reeves column are but slightly or very little increased or diminished in length or thickness the principle of the Reeves column will not be violated; but if the flanges become so large as to leave no segmental part between them, they become angle-irons, and differ in principle; and if the flanges of the segments become so small as to be mere ribs on the segments, or fins, the segments become flat bars, and differ in principle.

X-Q. 49. Calling your attention to your Exhibit B. cross-examination, suppose a post constructed of the form as therein shown, with distance-pieces extending outward from the centre interposed between the flanges and terminating at the outer edge of the flanges, would that be, in your opinion, the same in principle as the Reeves patented column?

A. If a column were so constructed it would be a Reeves patented column, consisting of segments with flanges, and filling pieces between the flanges; but such iron placed in the central part of the column would be badly placed, adding but very little to the transverse strength of the column.

X-Q. 50. Would the stiffness of the post be increased by such interposed distance-pieces?

A. The stiffness of such a post would be increased, but not as much as if the same iron were distributed around the periphery of the column, or between the section of the flanges.

226 X-Q. 51. Is the principle of a column of the form as shown in either of the drawings of Mr. Reeves' patent determined or controlled by the thickness of the iron in the segments between the flanges?

A. The principle of the Reeves column lies in the segments with flanges, they being united together through the flanges to make a unit: the iron in these segments is so proportioned as to make with a section of the flanges the requisite area. The segments are the principal part: the flanges of the segments are auxiliaries for uniting the segments to make a unit, to make a perfect column.

X-Q. 52. Suppose, on the one hand, a column of the form as shown in Figure 4, the segments thereof between the flanges being one inch in thickness, and, on the other hand, a column of the same form, the segments being say one-eighth inch in thickness, will the two be the same in principle, or will they differ?

A. If the segments with flanges so made, say one inch thick, and segments say one eighth inch thick, and their flanges so proportioned as to unite these different sections so as to make a unit, they will not differ in principle.

X-Q. 53. Will the principle remain the same, or differ, in the supposed case, if the flanges are of the same thickness as the segments between the flanges?

A. If the flanges are of the same thickness as the body of the segment, the principle of the segment, with its flanges, in the Reeves column, will not differ.

X-Q. 54. Calling your attention to your exhibit, (cross-examination, B.) will you state what is the thickness of the segments, and the flanges on the segments, of the posts therein represented?

A. The thickness at the body of the segment and the flanges, in a section represented, are so small that the thickness of the flange is drawn nearly as thick as that of the segments. The thickness of the segments as they increase require thicker flanges, but not in the same proportion as the thickness of the segments increase.

227 X-Q. 55. Cross-question 54 repeated.

A. The segments represented on the exhibit are drawn one-eighth of an inch in thickness, the flanges three thirty-seconds of an inch in thickness, and are drawn in the proportion to a column of the diameter represented.

X-Q. 56. Will you now make a drawing of the form as shown in Exhibit B, or Figure 4 of Reeves' column, of the same external diameter as in Exhibit B, the segments thereof being increased to one inch thickness, and the flanges bearing the same proportion thereto as the flanges in Exhibit B bear to their segments?

A. It would be impossible to draw these segments one inch thick the same diameter as in Exhibit B, and the body of the segments bearing the same proportion to the flange as in Exhibit B. You cannot make out of a flanged segment a piece of angle-iron.

X-Q. 57. Will you draw a post of the form, as in Exhibit B, (cross-examination,) of the same external diameter as the post in that exhibit, but with segments one-half inch thickness, and having suitable flanges on their edges, and suitably proportioned rivets?

A. I have made, and now produce, drawing marked "Bonzano, C," (cross-examination.)

X-Q. 58. Would a column constructed according to your Exhibit C above be the same in principle as the column patented to Mr. Reeves? You are requested to answer the question directly, yes or no.

A. I consider a column thus constructed a Reeves column, with distorted segments, made for a particular purpose, but with no aim for economy, strength, and proportion.

X-Q. 59. Cross-question 58 repeated, with the addition, will you give an answer in the affirmative or negative to cross-question 58, without observation or comment?

A. I cannot answer that question in any other way than I have done.

228 X-Q. 60. You have already testified, have you not, (cross-question 52 and answer,) that columns of the form as shown in Figure 4, with flanged segments one inch thick, on the one hand, and one-eighth inch thickness, on the other hand, would not differ in principle: do you adhere to that testimony?

A. I adhere to the answer I gave at that time. I say segments with flanges proportioned according to the thickness of the metal in the body of the segments do not differ from Exhibit B in principle.

X-Q. 61. And Exhibit B you consider as representing a Reeves column, do you not?

A. I do.

X-Q. 61½. Is not the proportion existing between the body of the segments and the flanges in Exhibit B the same as exists between the body of the segments and the flanges in your Exhibit C?

A. The proportion exists in regard to the thickness of the segment and flanges, but not as to the relative material in segments and their flanges: that is to say, in Exhibit C the flanges have nearly the same area as the segment, therefore being out of proportion.

X-Q. 62. Who made the drawing presented by you in your examination-in-chief, marked "Bonzano, No. 1?"

A. I do not know.

X-Q. 63. In said drawing the columns marked K and G, respectively, purport to represent the columns similarly lettered in the "Allgemeine Bauzeitung," do they not?

A. They do.

X-Q. 64. State in inches, if you know, the measurement of three-tenths meters?

A. Eleven and eight-tenths inches.

X-Q. 65. Is that, according to your understanding, the width of the flat bar interposed between the flanges in the Dutch post?

A. It is.

X-Q. 66. What is the thickness in inches of said bar in said Dutch post?

A. Forty-seven hundredths inches.

229 X-Q. 67. At whose instance, and under whose direction, were the tests testified to by Mr. Griffen, and referred to in your testimoney herein, (answer to questions 13 and 14,) made, and by whom were the same recorded?

A. Those tests of the Keystone and Phœnix columns, made at Phœnixville, June 25th, 1870, were made at the request of General Sorrell, chief engineer of the New Haven, Willimantic and Middletown Railroad. The results of these tests were made in my presence, Charles Hilton, chief engineer of the Hudson River Railroad Bridge Company, Juan Patterson, assistant engineer of General Sorrell; also in the presence of the officers of the Phœnix Iron Company's engineering department. The results were noted and recorded, both by myself, the chief engineer of the Phœnix Iron Company, their assistant engineer, and, I believe, also by the superintendent, Mr. John Griffen.

X-Q. 68. Have you seen the official report of said test made by said Juan Patterson to General Sorrell?

A. I have not, and doubt that he made one.

Re-examination:

Q. 69. Is there anything in the "Allgemeine Bauzeitung," coupled with the plate therein referred to, to indicate that the peculiarly-shaped angle-irons can be used without the cruciform centre-pieces to form by themselves an independent column?

A. There is no such mention made; the peculiarly-shaped angle-irons are described as holding the main part of the column—meaning the plates—in position.

A. BONZANO.

Affirmed and subscribed before me this 12th day of September, A. D. 1870.

JOHN RODGERS,
Examiner.

(The plaintiffs here produce "Exhibit Bonzano, No. 2," Plate A, of the Phœnix Iron Company's pattern sheets, illustrating the Reeves column in elevation, and several sections, with and without filling-pieces between the flanges.)

230 NOVEMBER 7TH, 1870.

JOHN C. TRAUTWINE, a witness produced on the part of the complainant, being duly affirmed, saith:

Question 1. What knowledge have you, as an engineer, of bridges and other structures in which Reeves' post can be used?

Answer. I have pursued both civil engineering and architecture as my profession for more than forty years, and have consequently familiarized myself with such structures as you refer to.

Q. 2. Are you familiar with that post, as described in his patent of 1862?

A. Yes.

Q. 3. Was that a new invention at that time, and in what did its novelty consist; and what are its peculiar advantages—first, theoretically, or in a scientific, mechanical point of view; second, practically?

A. To the best of my knowledge and belief, it was entirely new, and I so expressed myself to Mr. Reeves at the time, (early in 1862,) when he confidentially showed me his invention, asking my opinion of it, and informing me of his intention to patent it. He requested me not to mention it until he should have secured his patent. I congratulated him on his invention, inasmuch as a large wrought-iron hollow circular column was a great desideratum among engineers and architects. Until that time they had been compelled to resort to imperfect substitutes, formed in various ways, by uniting pieces of the different shapes of mercantile iron, known as T, angle, channel, &c., irons. I had long been familiar with these make-shifts, and was therefore much and favorably impressed with the marked superiority of Mr. Reeves' invention. Its novelty consists, among other things, in its being formed of three or more sections or staves, each of the same length as the column, and which, when riveted together, constitute a symmetrical hollow shaft, the transverse section of which is a circular ring, strengthened at intervals around its circumference by projecting vertical ribs. Another and important novelty is, that the form of these staves is such that, by
231 merely increasing their number, columns of different diameters may be made without the necessity of altering the pattern of the staves in any other way than by merely passing them through different grooves in the rolls, in order to modify the degree of curvature. A simple circular cross-section, or ring, had previously been considered the strongest form for a hollow column, made of a given quantity of metal; but I am inclined to the opinion that the addition of the projecting ribs or flanges of Mr. Reeves' column is at least as good, if not a better, way of disposing of a portion of the metal, instead of placing it all in the ring itself. But, independently of this consideration, they are of great service in many constructions, by affording a convenient and effective means of attaching braces or stays, or other accessory pieces.

Q. 4. What advantage results from this mode of fastening the pieces together through the flanges?

A. That the several pieces are so firmly united as to act as one. Moreover, the flanges afford a convenient means for making the attachment of braces and other collateral pieces frequently required in constructions.

Q. 5. What advantage in the use of more than two (2) pieces to form the body?

A. That columns of different diameters can be formed by staves of the same pattern, by merely increasing their number and altering the degree of their curvature; moreover, the strength of the column becomes more nearly equalized around its entire circumference.

Q. 6. Were those peculiarities new at the time of his patent?

A. To the best of my knowledge and belief, they were.

Q. 7. Have you examined Linville's post, as described in his patent of 1862?

A. I have.

Q. 8. Which, if any, of the peculiarities or claims of invention in Reeves' patent is contained in that of Linville's of 1862?

A. None.

Q. 9. Is there anything in Linville's patent of 1862 which describes or suggests a plan of making a post like Reeves'?

232 A. No.

Q. 10. Can you find anything there suggesting the mode of fastening the pieces together?

A. No.

Q. 11. What are the differences or difference in the modes of fastening in the two, and the effects produced by such mode?

A. The staves which compose Mr. Reeves' column are kept tightly together, in close contact, by means of rivets through their flanges, thus presenting the appearance of a solid symmetrical column. This is a peculiarity possessed by none of the forms before alluded to; and by this means not only does the column become appropriate to many architectural purposes, both interior and exterior, but rain, snow, dust, &c. are excluded from inside of it, thus preventing internal rust and trouble in cleaning. In view of the very general introduction which the column is meeting with for building purposes, these considerations are of great importance. In Mr. Linville's column, on the other hand, the staves are kept a short distance apart by means of "distance-pieces," which necessitate the use of short bolts (instead of the short rivets used by Mr. Reeves) for keeping them in place. Consequently Mr. Linville's column is an open one, admitting rain, dust, &c., and, moreover, is deficient in the architectural effect which characterizes the Reeves column. I conceive, likewise, that inasmuch as the staves of Mr. Linville's column are placed at some distance apart, they cannot act so unitedly as if they were riveted together in close contact, as in the Reeves column; or, in other words, that if, from imperfect workmanship, or from irregular settlement or unequal loading, the pressure on top of a column should be thrown unduly upon the stave, the other staves would not render as much assistance as if they were riveted tightly together.

Q. 12. What are the differences between them, as to the number of pieces of which the body or shaft is composed, and the effects or results of such differences?

A. Mr. Linville's has but two staves or vertical pieces, while Mr. Reeves' has three or more. I have already stated, as results
233 of three or more pieces, that columns of different diameters can be formed by staves of the same size, and, moreover, that the strength of the column is more equalized throughout its circumference; besides which, the greater number of staves involves a greater number of vertical flanges, and in many cases this is very important for facilitating the attachment of braces, stays, &c., which converge to the column from different directions.

Q. 13. Assuming that, under vertical pressure, Linville's post yields in the direction of the largest diameter of the combined post, what is the necessary inference in respect to the actual union or combination of the two pieces? Look at Linville's patent of 1865, relative to a post, and point out what claims for improvements, if any, are, and what are not, identical with Reeves' claim of 1862.

A. In Linville's patent of 1865 the claim for employing two, or more than two, vertical staves for making a hollow column, as well as that of forming these pieces with vertical flanges along their edges, for the pur-

pose of joining them together, appear to me to be identical with Mr. Reeves' claims in 1862.

Q. 14. What parts claimed by Reeves as novelties or inventions in his patent of 1862 are also described in Linville's of 1862?

A. None.

Q. 15. In your opinion, does Reeves' patent of 1862 infringe on any claim of Linville's in 1862; if so, in what particular?

A. No.

Q. 16. In what does Linville's of 1865 infringe on that of Reeves' in 1862?

A. In claiming the right to use more than two staves, and in uniting them by flanges.

Q. 17. Have you ever known Linville's of 1862 to be used, except at the arsenal bridge?

A. No.

Q. 18. To what extent is Reeves' of 1862 used, and for what purposes?

234 A. It is coming into very common use for pillars in stores, warehouses, and other buildings; for the vertical posts and for the upper chords or booms of iron bridges; for railroad trestle-work; and, in fact, for any other purposes for which a strong, symmetrical, close, hollow column or pillar is needed. Its mere application to some of these purposes has been patented, thus proving the estimation in which it is held, as well as its superiority over the various forms previously in use. I think that the Patent Office is censurable for this; for Mr. Reeves merely patented a new wrought-iron column, which he stated to be applicable to many engineering or architectural purposes; and I conceive that the Patent-Office is not justified in issuing patents for applications so self-evident, and which would, as a matter of course, suggest themselves to any engineer or architect who might need such a column. The fact, however, that such patents are taken out is, in itself, an evidence of the merit of the column itself.

Q. 19. Look at the drawing in the "Allgemeine Bauzeitung," and the text, as translated in the evidence in this cause, and state, first, is there any, and what, distinction between that column and the one patented by Mr. Reeves?

A. The two are as different as two things designed for the same purpose can well be. In the German column the mass of the material is placed near the axis, where it is least effective to resist either vertical or lateral forces; whereas in the Reeves column it is placed in the periphery, where it is most effective against both. This, in itself, constitutes a novelty so marked as to preclude all comparison between the two columns in point of combined efficiency and economy of metal, in which points they are diametrically opposed to each other. Again, the diameter of the German column cannot be increased by merely increasing the number of its pieces; whereas in the Reeves column it can; and this is an important feature, on the score of cheapness of manufacture. The flanges on the outside of the Reeves column afford an admirable means of attaching braces or other pieces frequently required in constructions. The German column is defective in this respect; the

235 vertical ribs of the German column are not at all adapted to resist strains brought upon them by forces acting laterally through the medium of attached stays, braces, &c.; whereas in the Reeves column the resistance to such disturbing forces is as perfect as it is possible to be in a hollow column.

Q. 20. Second, is there anything in that text or drawing which would

enable a skilled mechanic to construct a column such as is described in Mr. Reeves' patent?

A. Nothing. If there had been the Reeves column would probably have been in use before he devised it. The person who designed the German column would himself, in all probability, have been led to change it to the Reeves form.

Q. 21. Third, was there any novelty in Mr. Reeves' column after the design of the column in the "Allgemeine Bauzeitung" was published: if so, in what did the novelty exist?

A. It is entirely novel in the grand principle of furnishing an economical built hollow wrought-iron column, in which the material is disposed in the best attainable manner for resisting both the vertical and the lateral forces to which it may be exposed, and at the same time for securing that degree of architectural effect which renders it more suitable for many building purposes than any other wrought-iron column that has been devised. For general engineering and architectural purposes, there is no other that can be compared with it. Its introduction constitutes a marked era in the history of wrought-iron columns, and at once gave an entirely new impulse to the use of such in structures of various kinds. I do not hesitate to stake my professional character on the assertion that, in a plain common sense acceptation of my remark, the Reeves column is not only entirely novel, but is one of the most important and useful inventions that have been made in the art of construction for many years.

NOVEMBER 28TH, 1870.

Cross-examination by Mr. Collier:

X-Q. 22. Have you ever read the letters-patent of the complainant, Samuel J. Reeves?

236 A. I have.

X-Q. 23. When?

A. At various periods within several months past: last, perhaps, within about a month.

X-Q. 24. What do you understand as being the novel feature of the improvement described in said patent?

A. I consider that the chief novelty consists in its being a large, hollow, circular column of wrought iron, formed of three or more segments, connected together by exterior flanges, and having the material so disposed in its periphery as to secure a maximum degree of strength.

X-Q. 25. Suppose a column to be constructed having the characteristics mentioned in your answer, except that it is not large and is not circular, would it, in your opinion, be such as is described and claimed in said patent?

A. The matter of size I should not consider as having any reference to the point. I introduced the word large merely to indicate that that kind of column would furnish a large, round, hollow, wrought column, if required, which I believe cannot be done by any previous process. The column might also deviate somewhat from the circular form without altering my views as to the novelty.

X-Q. 26. Might it deviate to the extent of forming a square column without departing from the invention patented to Mr. Reeves?

A. It could not.

X-Q. 27. Then you think a column having the characteristics mentioned in your answer to cross-question 24, but forming in its cross-section a square, would not be embraced within the letters-patent of Mr. Reeves?

A. I think it would not.

X-Q. 28. Suppose a column to be constructed circular in form, and having the characteristics mentioned in your answer to cross-question 24, and having, in addition thereto, flat bars extending outwards from the centre of the column, and embraced by the flanges, would a
237 column so constructed be the same, or would it differ in principle from the column described in the letters-patent of Mr. Reeves?

A. I should consider such an arrangement as being a combination of Mr. Reeves's column, with other material less judiciously disposed than it is in Mr. Reeves's column, so far as regards the general uses of a column. I should consider such an arrangement as deviating, to some extent, from the principle of Mr. Reeves's column, inasmuch as it does not secure the same degree of strength with the same amount of material.

X-Q. 29. Would such bars add to the strength and efficiency of the column in which they were interposed?

A. They would; but not to the same extent as if the material were placed near the circumference.

X-Q. 30. You think a column composed of three sections or staves would be the same in principle with a column composed of five, six, or more staves, other things being the same; is that so?

A. I cannot conceive that the exact number of staves produces any effect upon the principle involved.

X-Q. 31. Will you explain what difference, if any, in principle, would exist between a column composed of two sections or staves, on the one hand, and a column composed of three sections or staves, on the other hand, other things being equal?

A. By an increase in the number of the staves, the strength of the column is somewhat equalized around the circumference; beyond this, I do not think of any other difference, except that a column of three or more staves is attended by certain facilities of manufacture which do not pertain to the column of two staves.

X-Q. 32. Does the convenience, or inconvenience, as the case may be, in the "manufacture," affect in any manner the principle of the manufactured column, whether it be formed of two staves, on the one hand, or three or more, on the other?

A. I cannot see that the process of manufacture in any way affects the principle of the finished column in any case.

X-Q. 33. Suppose a circular column to be constructed of two sections or staves having all the characteristics mentioned in your answer
238 to cross-question 24, would such a column be the same in principle, or different, as that described in the letters-patent of Mr. Reeves?

A. It appears to me that the principle would be the same, as regards the finished column, in both cases.

X-Q. 34. Is it not customary, in the manufacture of wrought-iron hollow columns, to increase the number of staves or sections where a column of large diameter is required, and is not the converse of this true?

A. I do not at this moment recollect any hollow wrought-iron columns of large size, except those of Messrs. Reeves and Linville. Many forms of wrought-iron pillars which, in my opinion, could not be called hollow in the ordinary acceptation of the term, are made of three or more staves, the number of staves in certain instances being increased in order to furnish the requisite strength: but, as a general rule, their shape is such that the increase in the number of pieces can hardly be said to increase their diameter, but merely the quantity of resisting

material. I allude, of course, to cross-shaped, &c., columns. There are other shapes, however, such as squares, &c., which may constitute hollow columns, and in which the diameters would, of course, be increased by making each side of more than one stave. It is not impossible that such have been made, but I do not at present recall of any such. Further than this, I know of no precedent whatever in the matter of large, hollow, wrought columns, except those known as the Reeves and Linville; and I believe it is customary with both of those gentlemen to increase the number of staves when they wish to form a large column, and, of course, to use a smaller number of staves when they wish to form one of smaller diameter.

X-Q. 35. In the construction of a column, say of three inches diameter, would it not be more convenient and more economical to make it of two staves or sections rather than of three or more?

A. That would depend entirely upon the purposes for which the column was to be devoted. For instance, in columns for supporting
239 certain portions of machinery by pillars of small size, and supposing rolls to be already constructed for the manufacture of both kinds of segments, I conceive that it might still be expedient to employ three segments or more instead of two. This, however, I conceive to be a matter pertaining more to the province of the iron manufacturer than to the civil engineer.

X-Q. 36. Having stated in your answer to cross-question 27 that a wrought-iron hollow-flanged column in the form, as to its transverse section, of a square, would not be embraced in the letters-patent of Mr. Reeves, I will ask you whether your opinion, as expressed in your examination-in-chief, that the post described and shown in "Allgemeine Bautzeitung," is different in principle from Mr. Reeves', is based upon your belief that Reeves' patent does not include a square column?

A. No; it is not based upon that fact.

X-Q. 37. Upon what do you base the opinion that the post in "Allgemeine Bautzeitung" differs, in principle, from the Reeves post?

A. It is based upon the fact that I can see no resemblance whatever between the two columns, except in such general particulars as that they are both made of wrought-iron staves; that both have a top and a bottom, &c., &c.

X-Q. 38. The column in "Allgemeine Bautzeitung" presents the form of a square in its transverse section; while the Reeves column, as you have described it, presents the form of a circle, or a near approximation to a circle, in its transverse section. In these respects the two differ. Does such difference affect the principle of the two in any degree, in your opinion?

A. Although the German column presents the form of a square in its transverse section, still the form of its transverse section is by no means a square, but a cross; whereas in the Reeves column the transverse section not only presents a circle, but is itself a circle. The question, as to what affects the principle of the respective columns, is one of too general import to be understood or answered in a satisfactory man-
240 ner, unless the nature of the principle alluded to is more expressly defined.

X-Q. 39. Suppose you have, on the one hand, a wrought-iron hollow column, formed of four staves with flanges upon their edges, and united together by rivets passing through the flanges, the transverse section of the column being a square, and, in the other case, you have a wrought-iron hollow column, formed of four staves with flanges upon their edges, and united together by rivets passing through the flanges, the transverse

section of the column being a circle, diameters being the same; which column would be, and which, if either, would not be, comprehended in the description contained in the letters-patent of Mr. Reeves?

A. Upon this moment, glancing over Mr. Reeves' patent, it appears to me that a square column, with the flanges rolled upon its staves and forming a part of them, as in the Reeves column, and riveted together in the same manner as in his column, would be fully embraced in his patent. I conceive, it appears to me, that both columns would be embraced in his patent. This moment, referring to the drawings alluded to in Mr. Reeves' letters-patent, I find that such a square column is embraced in said letters, a fact which had escaped my memory at the moment the question was asked.

X-Q. 40. Then you wish to retract entirely, I presume, your answer to cross-question 26?

A. Yes, by all means. At the moment of giving that answer, I had forgotten that Mr. Reeves claimed the application of his patent to square forms as well as to circular ones; and inasmuch as the circular form is that which secures the greatest strength in the column, and inasmuch as I had considered this as one of the features involved in the Reeves column, my answer to said question is most evidently erroneous.

X-Q. 41. In your answer to cross question 38 you say, "although the German column presents the form of a square in its transverse section, still the form of its transverse section is by no means a square,
241 but a cross;" will you explain more fully the meaning intended to be conveyed by the language quoted?

A. I mean that the form of a cross is not as well adapted to the securing of the full strength of the material, when in the shape of column, as the circular form is; and I will now add, as the hollow square, both the circle and the square, both being better forms of transverse sections for a column than a cross is, inasmuch as in the last the material is concentrated more near the axis of the column than it is in either the circle or the square.

X Q. 42. You rather mean, do you not, that the German column is a square column in its transverse section, with flat bars interposed between the flanges of the column and extending to its centre; is not that so?

A. No; that is diametrically the reverse of what I intended to express. I do not consider the German column to be, in any sense of the word, a hollow square. Literally, or in point of fact, there certainly is a small square (or rather, if I recollect rightly, four small squares) at its axis. But the area of this square, or of these squares combined, is so small, in comparison to the quantity of the material employed in the pillar, that the pillar can by no means be called a hollow square, in a practical sense of the word, as would be generally understood by engineers, architects, machinists, &c., but is simply and truly a cruciform pillar, in which the small hollow area at or near its centre appears to have been an accidental occurrence, based upon the fact that the two sides of the angle-iron which formed the flanges do not, as usual, come together at a sharp angle.

X-Q. 43. (Witness is shown exhibit marked "Defendants' Exhibit, Trautwine, 1," and asked:) Please examine the exhibit now shown you, and state whether a column constructed of wrought-iron staves similar to this exhibit would be the same in principle, or different, from the column described in the letters-patent of Mr. Reeves, and whether

it would be the same, or different, in principle, from the German column.

242 A. I conceive that a column constructed in this manner would be identical with that embraced by Mr. Reeves' patent, except as regards the addition of the two diagonal bars. I conceive that it would differ from the principle of the German column materially, inasmuch as in the model exhibited the material is so disposed that, in a practical sense, the form of the column might be described as a square cellular one; the large amount of vacant space near its axis now changes its character from that of a strictly cross-shaped more to what I would understand as a cross combined with a hollow square.

X-Q. 44. Assuming the existence, prior to the alleged invention of Mr. Reeves, of a wrought-iron column constructed according to this exhibit, what novelty, if any, would you find in the letters-patent of Mr. Reeves?

A. None but the omission of the cross in the side of the hollow square.

X-Q. 45. And would that, in your opinion, affect the principle so as to constitute the two posts different in principle from each other?

A. If Mr. Reeves' patent is based upon no other principle than that of the omission of the cross from a column otherwise constructed precisely as he constructs them, then I should conceive that Mr. Reeves has no claim whatever.

X-Q. 46. Assuming the existence and knowledge of a column of wrought iron precisely in size and other features as the Exhibit 1 prior to the alleged invention of Mr. Reeves, what, if any, novel feature do you, in such case, find in the letters patent of Mr. Reeves?

A. Nothing but the omission of the cross.

X-Q. 47. And does that constitute a change in principle, other things being equal?

A. In my opinion it does not constitute such a change of principle as would warrant Mr. Reeves in making any claim to novelty, or a claim to anything new, as a manufacturer.

X-Q. 48. (The witness is now shown defendants' exhibit, marked
243 "Trautwine, 2," and asked:) Will you please point out the difference in principle between two columns of wrought iron—the one constructed according to Exhibit 1, and the other according to Exhibit 2?

A. The principal difference that I see is, that in this model, 2, the mass of the material appears to be disposed nearer to the axis of the column than in Exhibit 1; so that Exhibit 2 is arriving at that point in which it is difficult to determine whether, in a grammatical sense, it would be more correct to call it a cruciform column, or a hollow square combined with the cruciform. It is quite impossible in these cases, as in almost everything else, to fix exact limits between forms whose extremes differ very essentially from each other in nearly every respect.

X-Q. 49. Suppose you have a column constructed according to Exhibit 2, except that it has one flat bar passing between the flanges upon the two opposite sides of the post, and through the body of the post, would such a column be the same, or different in principle from Exhibit 2?

A. It is difficult to say, on the spur of the moment, in how many different ways the withdrawing of one arm of the cross might be said to alter the principle of the pillar; the chief difficulty, perhaps, consisting in understanding perfectly the force of the expression, "change of principle," as applied in this case.

X-Q. 50. I understand you as testifying that a column constructed according to Exhibit 1, shown you, would be within the letters-patent of Mr. Reeves; am I correct?

A. No; that is not my opinion: the reason why I do not think so is, that in a column constructed on the principle of Exhibit 1, the material forming the cross is not disposed to as great advantage as it is in what is popularly understood by a hollow column, either circular or square, as Mr. Reeves'.

X-Q. 51. And for the same reason you think that a column constructed according to Exhibit 2 would not be within his patent; am I correct?

244 A. My previous answer applies with more force to Exhibit 2 than to Exhibit 1, because in Exhibit 2 a large proportion of the material is withdrawn from the periphery and disposed near the axis.

X-Q. 52. Would the principle pertaining to columns, such as Exhibit 1 and 2 respectively, be affected; and, if so, how, by enlargement of the columns?

A. It appears to me that the principle is not dependent upon the actual size of columns so much as upon the proportions of their several parts; and, hence, I conceive that the same principle would operate about equally in columns of the same figure, but of different sizes.

X-Q. 53. Would columns constructed according to Exhibits 1 and 2, respectively, be the same, or different, in principle?

A. I would say, if the concentration of the material of a column at its circumference, as a means of increasing the strength, constitutes a principle, than any column in which the mass of the material is concentrated near the axis must be held to deviate from that principle; while, on the other hand, so long as all the material is not absolutely concentrated around its axis, the column must be said to partake in some degree of that principle; so that the question appears to me to refer, not so much to the presence of a certain principle, as to the extent to which that principle is carried out. Two columns may be constructed, in each one of which is contained every principle that is contained in the other, yet one of the columns may be very superior to the other, in consequence of the difference in the extent to which some of the principles are applied in one column more than the other.

X-Q. 54. Cross-question 53 repeated.

A. To what principle do you refer? As I understand the question, I have replied to it in the preceding answer.

X-Q. 55. Assuming the existence of a column such as shown by model, Exhibit 1, would the construction subsequently of a column such as shown by model (Exhibit 2) be, in your opinion, a novelty or an independent invention?

A. It certainly would not.

X-Q. 56. Why not?

245 A. Because one of them very readily suggests the other, if the occasion should require the change to be made.

X-Q. 57. I have understood you to say that the Exhibit 1, without the interposed flat bars, is exactly in accordance with the letters-patent of Mr. Reeves; am I correct?

A. It appears to me that you are correct; the only difference that I see being a slight one in the proportion of the various parts; and I should consider that a column like Exhibit 1, except with the omission of the cross, would be in strict accordance with Mr. Reeves' patent.

X-Q. 58. In the letters-patent of Mr. Reeves it is stated as follows: "The stiffness and strength of columns made in this manner may be in-

creased, at a very moderate expense, by setting plain bars of iron between the flanges of the bars *a a a a* and riveted to them, and extended outwards from the centre, thus, in effect, increasing the diameter of the column." In view of this language, I ask you whether Exhibit 1, with the plain bars interposed between its flanges, does not conform to the description as contained in Mr. Reeves' patent?

A. If Mr. Reeves means that his flat bars should extend inwards to the very centre of the column, then I conceive that the answer to your question should be, yes. (My belief is that iron bars inserted between the flanges, as is practiced by Mr. Reeves, or as in the column like Exhibit 1, is a wasteful mode of disposing of the material, and that it could be better applied in the periphery of the column.)

(That portion of the answer in parentheses objected to by counsel for the Keystone Bridge Company, as being irresponsive to the question, and argumentative, and the question repeated.)

X-Q. 59. Cross-question 58 repeated.

A. The grammatical construction of the extract from Mr. Reeves' letters-patent leaves me in doubt whether, when he says, "extending outwards from the centre," he actually means to include bars extending inwards towards the centre. The practice of Mr. Reeves is to insert bars, in the manner alluded to, and extending outwards in a direction from
246 the centre, but he never extends them actually from the centre: the direction is outwards from the centre, but the bars are not outwards from the centre.

X-Q. 60. What do you understand by the centre of the column?

A. I understand what mathematicians understand, "the centre of the figure."

X-Q. 61. Do not the flat bars in Exhibit 1 extend outwards from its centre?

A. They do in both acceptations of the term: not only the direction of the bars, but the bars themselves actually extend outwards from the centre.

X-Q. 62. Assuming that the model (Exhibit 2) correctly represents one of the forms of the German column, ("Allgemeine Bautzeitung,") I ask you, in view of the language I have quoted from the letters-patent of Mr. Reeves, whether you have any modification to make of your testimony-in-chief, to wit, that the two columns (Reeves' and the German) are "diametrically opposed to each other?"

A. I would say that Exhibit 2 does not represent the German column, upon which I based the assertion in my examination-in-chief, or at least it does not represent it sufficiently to justify the application to it of the same remarks as might with propriety be made with regard to the other: but, assuming that it does represent the German work, my remarks, of course, will be applicable so far as the resemblance exists. If it is identical with it, I do not wish to modify my previous remarks.

X-Q. 63. I understood you then thus: assuming that the model (Exhibit 2) is an exact counterpart of one of the forms of the German post, you adhere to the opinion that it is diametrically opposed to the column described in the letters-patent of Mr. Reeves; am I correct?

A. In that case I do not adhere to that opinion.

X-Q. 64. Upon the same supposition, that is, the correct representation of the German post by this model, No. 2, would the construction
247 subsequently of a column such as is described and shown in Reeves' patent be, in your opinion, a novelty or an independent invention?

A. I would say, so far as Mr. Reeves' letters-patent refer to a square

column, I should not so consider it a novelty. I should not consider the mere omission of the cross-pieces as entitling a manufacturer to a patent-right, unless it should appear that the cross-pieces were originally intended to constitute the chief reliance of the column, and the sides were merely added to give stability to said cross-pieces; which does not appear to be the case in model No. 2. I do not think there would be patentable novelty in omitting the cross-pieces from a post such as Exhibit No. 2, in which the side-pieces cannot be, by any means, regarded simply as stays for the cross-pieces.

X-Q. 65. Referring to the examination of complainants' witness Bonzano, (answer to question 3 in chief,) wherein is contained a translation of the text of "Allgemeine Bautzeitung," will you state whether you do not find in said work a distinct recognition of the advantage of spreading the material of the column in its periphery, so as to leave hollow spaces in the body of the column; in other words, is not such fact there stated as pertaining to the post therein described, and is not also the advantageous effect thereof set forth?

A. I say, decidedly, yes; both principles appear to be distinctly recognized, although their application to the case alluded to is on but a limited scale, and does not constitute the main controlling feature, as it does in Reeves' column, in which the main dependency is evidently in the periphery, while in the German columns it is chiefly in the radii.

JOHN C. TRAUTWINE.

Sworn and subscribed before me this 28th day of November, 1870.

JOHN RODGERS,
Examiner.

248 SEPTEMBER 20TH, 1867.

Present: Mr. McMurtrie, Mr. Collier.

ADOLPHUS C. BOTH, being duly affirmed, doth depose and say:

Question 1. Where do you reside, and what is your occupation?

Answer. I reside at No. 912 Filbert street, in the city of Philadelphia, and am a draughtsman and mechanical engineer.

Q. 2. Of what country are you a native, and where were you educated, and for how long have you been a mechanical engineer?

A. I am a native of Germany; was educated at the polytechnic schools of Hanover and Carlsrhue, and have been a mechanical engineer since 1865.

Q. 3. Are you sufficiently familiar with the German and English languages as to be able to translate the one into the other?

A. I believe that I am able to make such translations readily.

Q. 4. Calling your attention to "Allgemeine Bauzeitung," page 215, will you please translate the same literally into English?

A. I will; and do now present the following, which I believe to be a true translation of the paragraph to which my attention is called: "General arrangement of the building. On columns of cut stone, which are connected to each other by brick arches, are placed other columns, A A, of iron, in distances of 3.76 metres, which extend through the entire heights of the building. These iron columns, whose sections are shown on Plate 440, Figure 5, K and G, consist of a flat iron bar, .30 metres by twelve millimetres thickness, which forms the principal centre body of the column; at right angles to this are connected two other irons of .12 metres breadth by 12 millimetres thickness, by means of peculiarly-shaped angle-irons so as to form a hollow space in the centre of the combination, which produces an increase of the rigidity of the

column, while the sectional area, which is necessary to resist the compressive strain, is not increased."

Q. 5. Are you familiar with the term angle-iron, as used by iron-workers and by engineers? if so, please give the meaning of such term.

249 A. I am familiar with the term angle-iron; by it is meant a piece of iron having two straight flanges that meet and are united at a common point or vertex; the sides may make any angle, either right angle, acute angle, or an obtuse angle.

Q. 6. The angle-irons forming the outer casing or shell of the posts in "Allgemeine Bauzeitung" are called in the text "peculiarly-shaped angle-irons;" will you please state wherein consists their peculiarity?

A. It consists in the fact that the flanges do not meet in a common point or vertex, but the flanges project from a straight bar of iron, to which they are attached, and by which they (the flanges) are separated from each other. In other words, the plates in "Allgemeine Bauzeitung" show straight, flat bars of iron with flanges on their edges.

Q. 7. What is the effect of uniting together two or more angle-irons in the form of a post for a bridge or other structure; what kind of a post is produced?

A. If two only are united together, a solid post is the result; if four are united, a solid cruciform post is the result.

Q. 8. What is the effect of uniting together four of such peculiarly-shaped angle-irons as are described in "Allgemeine Bauzeitung," and shown in the plates of said work?

A. A post is produced which is not solid, but hollow, and such posts will be composed of four pieces of flanged wrought-iron united together by rivets passing through the flanges.

Q. 9. Do you find any advantage attributed in said work to a hollow post? if so, state what you find.

A. I do find an advantage spoken of. It is this: by means of peculiarly-shaped angle-irons, so as to form hollow spaces in the centre of the combination, which produces an increase of rigidity of the column, while the sectional area, which is necessary to resist the compressive strain, is not increased. This, as it appears to me, clearly defines the advantage of the hollow column.

Q. 10. Assuming any given standard as measuring the capacity of the posts in "Allgemeine Bauzeitung" to resist compression, how
250 could the same resisting power be attained in a solid post?

A. Only by making its area greater than the post in the "Allegmeine Bauzeitung," so that in attaining the same strength greater weight and greater quantity of material would be required.

Q. 11. Assuming the employment of the same amount of material as in "Allgemeine Bauzeitung" in the construction of posts, the sections of which are not peculiarly shaped, but of ordinary angle-irons, what kind of a post would you have, and how would its strength compare with that in the "Allgemeine Bauzeitung?"

A. The result would be a solid post, and such post would be of less strength than the post shown in "Allgemeine Bauzeitung."

Q. 12. Is there anything in the text or plates of "Allgemeine Bauzeitung," if so, what, in reference to the object or purpose for which the bars between the flanges in Figures K and G are employed?

A. The Plates 437 to 440, inclusive, clearly show that the flat bars are employed for the purpose of enabling attachments to be made between said flat bars and the other portions of the structure in which said posts were employed.

Q. 13. Wherein, if at all, do the peculiarly-shaped angle-irons in "Allgemeine Bauzeitung" (K and G) differ from the "flanged pieces in the column of" Mr. Reeves' patent, (Figure 4)?

A. There is no difference except in size. Mr. Reeves' flanged pieces are merely an enlargement of the others.

Q. 14. In the patent of Mr. Reeves it is stated: "The stiffness and strength of columns made in this manner may be increased, at a very moderate expense, by setting plain bars of iron between the flanges of the bars *a a a a*, and riveted to them, and extending outwards from the centre, thus, in effect, increasing the diameter of the column." Suppose a column constructed according to Mr. Reeves' patent, with the configuration of his Figure 4, and with the bars set between
251 the flanges, as stated in the passage quoted, wherein, if at all, would such post, as an entirety, differ from Figure G in "Allgemeine Bauzeitung?"

A. It would not differ in the slightest respect.

Q. 15. (Counsel for Keystone Bridge Company introduces drawing marked "Both 1," and asks:) State by whom the drawing above referred to was made.

A. It was made by myself.

Cross-examined by Mr. McMurtrie:

X-Q. 16. What are the words in the text of the "Allgemeine Bauzeitung" which you translate peculiarly-shaped angle-irons?

A. Eigenthuemlich geformter winkeleisen.

X-Q. 17. Which of those words you translate "angle?"

A. Winkel, which means angle, and eisen means iron.

X-Q. 18. What words of the text indicate the use of connecting flanged irons to form a post without using the cruciform centre-piece?

A. The text does not say anything, but the plates clearly show it.

X-Q. 19. What are the relative lengths of the flanges, and of the piece between the flanges, in the "Allgemeine Bauzeitung?"

A. Those are indicated on Figures 6, 8, and 9, in Plate "Both 1."

X-Q. 20. In the text, is not the cruciform centre-piece described as the principal part of the post?

A. The text says that the flat bar—$1\frac{3}{10}$ millimetres by 12—forms the principal centre body of the column.

X-Q. 21. Does not the text state that the object of these flanged irons is to connect that principal body of the column with two other flat bars placed at right angles to the bar forming the principal body?

A. It does; but at the same time it does refer to hollow spaces produced by those peculiar-shaped angle irons.

252 X-Q. 22. Where, then, do you find in that book anything which indicates an intention or design to use these connecting pieces to form a post, omitting the principal body of the column and the flat bars to be connected therewith?

A. Figure K, Plate 440, shows two plates which do not extend from the centre, but only go as far as the flanges of those peculiar-shaped, angle-irons.

X-Q. 23. Would there be, in your opinion, anything of novelty in constructing a column according to Figure K, omitting the centre flat bar and the two cross flat bars?

A. I would not consider it a novelty, because posts have to be made very frequently out of common angle-iron without interposing any pieces.

X-Q. 24. In making a post according to Figure K, and supposing the

same area of iron, what is the advantage of placing that iron in the cross-sections, as there exhibited, or only in the flanged pieces?

A. There would be an advantage, and that would be an increase of the rigidity of the post, as well as an increase of the carrying moment.

X-Q. 25. If, then, this mode of construction has these advantages over the modes suggested by Figure K, how can you say that after the plan as in Figure K had been suggested, there would be nothing of novelty in the other plan?

A. I do not consider an enlargement of these peculiarly-shaped angle-irons shown in "Allgemeine Bauzeitung" a novelty. What results by increasing those irons, in obtaining far greater rigidity and carrying moment, has nothing to do with the principle.

X-Q. 26. You seem to forget, in your answer, that one of the main distinctions lies, not only in increasing the proportions of the flanged iron, but in withdrawing all the iron from the so-called principal centre body, and placing it in what were merely connecting pieces, and you admit that by so doing advantages are gained; do you still say there is nothing of novelty in that suggestion?

253 A. I believe that there is no novelty, according to my knowledge, as solid cruciformed posts have to be made without intermediate pieces, and therefore I think posts can be made of those peculiar angle-irons without intermediate or filling pieces.

X-Q. 27. Do I understand you to mean that there is no novelty because the practice of making the posts with angle-irons was already well known?

A. I think that the engineer of said posts combined the benefit of a hollow post, which theory, a long time ago, has shown to be beneficial, with the use of the angle-irons.

X-Q. 28. When did you first see that combination of angle-iron with the theory of a hollow post having no material in the centre?

A. I saw it after I was engaged by Mr. Linville and the Keystone Bridge Company.

X-Q. 29. Was that the first time you saw it?

A. The first time; at least the first time that I paid any attention to it. This was in November, 1869.

X-Q. 30. Do you consider that a hollow post formed of flanged iron pieces bolted through the flanges to be useful in the construction of bridges and other structures?

A. Yes, I think I do.

X-Q. 31. Is it not extremely useful?

A. I think it is, as it gives at the same time a well-looking post.

X-Q. 32. Has it not practically superseded all other forms of posts and struts in the construction of railroad iron bridges?

A. As far as my knowledge goes, it has.

A. C. BOTH.

Affirmed and subscribed before me this 26th day of September, A. D. 1870.

JOHN RODGERS,
Examiner.

254 SEPTEMBER 27TH, 1870.

Present: Mr. McMurtrie and Mr. Collier.

JACOB H. LINVILLE, being recalled, saith:

Question 1. The witness being shown Exhibit "Both 1," is asked, Who caused this drawing to be made?

Answer. I did.

Q. 2. Are you familiar with, and able to explain, what is intended to be represented by said drawing?

A. I am.

Q. 3. What is represented by Drawings G and K, Figures 8 and 9, respectively, on said exhibit?

A. They represent sections of posts as shown in Figures G and K, Plate 440, "Allgemeine Bauzeitung," drawn to the natural size by scale, according to the dimensions marked thereon.

Q. 4. What is represented by Figures 5, 2, and 1, respectively, in said exhibit?

A. Figure 5 represents one of the peculiarly-shaped irons or flanged pieces used in the construction of Figure 9. Figure 2 is an expanded section of the flanged piece, similar to Figure 5. Figure 1 is a similar section, the flat portion connecting the flanges being expanded still more than in Figure 2.

Q. 5. What is repsenented by Figure 6, and what by Figure 7?

A. Figure 6 represents a square hollow post, composed of flanged pieces such as are used in the construction of the post, Figure 9, K. Figure 7 represents a square hollow post, formed of the expanded flanged pieces such as are represented in Figure 1.

Q. 6. What is represented by Figures 4 and 3, respectively?

A. Figure 4 represents an ordinary angle iron; the portion left white being intended to represent a corner of said angle iron cut off; the shaded portion representing the portion of the angle-iron that would remain after the corner had been cut off. The shaded portion of Figure 3 represents a section such as are used in the construction of post, Figure 8. If the exterior sides were extended to meet in a point, they would be of
255 the same length as the sides of the angle-iron, Figure 4. The dotted lines in Figure 3 indicate the configuration of the angle-iron if applied to Figure 3. The object of the dotted lines in Figure 3 and the drawing, Figure 4, is to illustrate the fact that if a corner were cut off an ordinary angle-iron, the thin film remaining to connect the flanges would be entirely useless for practical purposes, and that it is impossible to reduce the section of Figure 3 and the sections used in Figure 8 to an ordinary angle-iron with the corner cut off, since in Figure 3 there is a flat portion connecting the two flanges, while in an angle-iron flanges are usually connected by a concavity.

Q. 7. What is represented by Figures 15 to 10 inclusive?

A. Figure 15 represents a circular hollow post made of four flanged pieces, such as are constructed under my patents and those of Mr. Reeves. Figure 14 represents one of the flanged pieces used in constructing a four-inch octagon post, such as are rolled in the Union Rolling-Mills for the Keystone Bridge Company. Figure 13 represents an ordinary angle-iron, the shaded portion showing what would remain after cutting away a corner, such as would form a circular hollow space, if four of such pieces were combined into a post. Figure 12 represents a flanged piece, four of which, being combined together, would form a circular hollow post; if the exterior sides were extended to meet in a point, their length would be equal to that of the angle-iron in Figure 13. The dotted lines on Figure 12 indicate the configuration of the angle-iron, Figure 13, applied to Figure 12. These figures, 13 and 12, in conjunction with 3 and 4, are intended to show that Figure 3 is no more an angle-iron with the corner cut off than a section, used under Mr. Reeves' patent to form a hollow post, is an ordinary angle-iron with the corner cut off. In both cases there remains simply a thin film con-

necting the two flanges, entirely useless for practical purposes. Figure 11 represents a section similar to Figure 12, expanded by extending the portion that connects the flanges. Figure 10 shows the same form or kind of section, the portion connecting the flanges being still further extended.

256 Q. 8. What is represented by Figures 16 to 18 inclusive?

A. They represent that hollow posts may be formed under our patent and that of Mr. Reeves by using sections shown in the previous figures combined with flat bars interposed between the flanges.

Q. 9. What is represented by Figures 23 to 19 inclusive?

A. They represent series of ordinary angle-irons, increasing in size regularly from Figure 23 to Figure 19.

Q. 10. What is represented by Figures 26 to 24 inclusive?

A. Figures 26 to 24 represent cruciform solid posts, composed of ordinary angle-irons, such as are shown in Figures 23 to 19, with flat bars interposed between the angle-irons.

Q. 11. (Counsel for Keystone Bridge Company introduces wrought-iron sections, marked Exhibits, Linville, 2, 3, and 4, respectively, and calling the attention of the witness thereto, asked:) What is represented by the said exhibits, respectively?

A. Exhibit 2 represents two ordinary T-irons, placed together, back to back, so as to form a cruciform solid post. Exhibit 3 represents four ordinary angle-irons, placed together, back to back, with their vertices meeting at a common point in the centre, so as to form a solid cruciform post. Exhibit 4 represents a hollow octagon post four inches exterior diameter, being one size of post such as is made by the Keystone Bridge Company from the sections rolled by the Union Rolling-Mills.

Q. 12. Taking Exhibit 3, and supposing that the corners of each of the angle-irons was cut off, would that which remained represent the sections of the post as shown in "Allgemeine Bauzeitung," G and K, respectively?

A. It would not.

Q. 13. If the corners were so cut off, could that part which remained be employed advantageously in the construction of a column; and, if not, why not?

A. If any considerable corner were cut off it could not be advantageously employed, for the reason that the portion remaining to connect the flanges would become very thin and insufficient for the purpose of connecting the flanges.

257 Q. 14. As you expand the dimensions of the flanged sections, or peculiarly-shaped angle-irons shown in "Allgemeine Bauzeitung," (illustrated in Exhibit Both, 1,) what is the effect?

A. The effect is to spread the material away from the centre towards the periphery of the column, thus increasing the hollow spaces, and consequently securing greater rigidity and strength than would be secured by the same amount of metal formed into a solid post.

Q. 15. As you expand the dimension of the ordinary angle-iron, as shown in Figures 23 to 19, inclusive, Exhibit Both, 1, what is the effect?

A. The effect is the very converse of the other; that is, in proportion to such expansion, the weight of metal is increased in the centre of the post, thus producing a post of less and less efficiency in proportion to the weight of material employed.

Q. 16. As you expand the dimensions of the sections of the post as described in your patent and in that of Mr. Reeves, what is the effect?

A. It is the same as stated by me in reference to the post in "Allgemeine Bauzeitung," in answer to question 14.

Q. 17. Do you think the principle, as pertaining to the post shown in "Allgemeine Bauzeitung," would be affected, and, if so, how, by removing the flat bars from between the flanged pieces?

A. If they were removed, and the dimensions of the flanged pieces remained the same, the post would not be as strong as with the flat bars. If they were removed and their material was employed in enlarging the area of the flanged pieces, the post would be stronger. In other words, the material composing the flat bars would be more economically employed, so far as strength is concerned, if it formed part of the flanged pieces rather than being used as it is. To this extent such change would be advantageous; so far, however, as enabling outside connections to be made, the interposed flat bars are an advantage, and their removal would necessitate a substitution of some other mode of attachment. Whether, then, the advantage in strength resulting
258 from the removal of the flat bars and employment of their material in the flanged pieces would compensate for the disadvantage spoken of would depend wholly on the particular combination in which the posts were to be employed. In my opinion, the principle of the post remains the same, whether the flat bars are or are not inserted between the flanged pieces, it being in both cases a hollow wrought iron column of flanged pieces. That the insertion of the flat bars does not affect the principle is distinctly stated in the patent of Mr. Reeves.

Cross-examined by Mr. McMurtrie:

X-Q. 18. When did you for the first time see a column, such as is Exhibit 4, or made of any form of rolled iron with flanges, so united so as to form a hollow post?

A. I had working drawings of a hollow circular column made of four flanged pieces, such as is shown in Figure 15, drawn to scale, to show the construction of such a column, prepared in the latter part of 1860. Early in 1860 numerous sketches were made of similar columns. The first column of this description I saw actually constructed or riveted together was the one sent to Altoona by Mr. Reeves. I saw it when it arrived there.

X-Q. 19. In Figures 1 to 5 (Both 1) do you merely expand the dimensions; do you not vary the proportions so that the flanges become relatively smaller than the flat bar?

A. The flanges being used merely for the purpose of connecting sections together, have not been expanded in the same proportion as the flat bar connecting the flanges, the object of the expansion being to increase the diameter of the post and enlarge the hollow spaces; the object of the flange being to connect the bars together, it is only made of the size necessary for the purpose, the size of the flange being optional with the party making the post, and not affecting the principle of the post.

X-Q. 20. Is that the only object of the flange of an angle-iron?
259 A. I have not been speaking of ordinary angle-irons, but of peculiarly-shaped angle-irons, or flat bars with flanges on their edges. With reference to them I believe I have stated the object clearly.

X-Q. 21. Is not Figure 4 an angle-iron?

A. Figure 4 represents an ordinary angle-iron.

X-Q. 22. In Figures 8 and 9 do not the centre pieces and the flanges constitute very much the larger part of the whole column?

A. In these sections Figures 8 and 9, which represent square hollow posts of very small diameters, composed of the small-sized sections of flanged iron, such as Figure 3, the flat bars and the flanges, taken in the

aggregate, would contain more material than is contained in the four posts. Figure four, short, flat bars connecting the flanges. These proposed additions, extending in my opinion, affect the principle of the column, since hollow posts of this form are introduced for the expressed purpose of increasing the bearing power of the pillar, or increasing the rigidity of the column.

X-Q. 23. What is the diameter of the column represented by the Figure 8?

A. Very nearly three inches.

X-Q. 24. Is there any distinction, in principle, between a post composed of four angle-irons riveted together, back to back, leaving no hollow space, and a post formed of four flanged pieces, forming a hollow square, as in Figure 7 (Both 1)?

A. There is a distinction in principle.

X-Q. 25. What is the distinction?

A. In a post formed of four angle-irons, riveted together, back to back, the mass of the material is disposed at the centre, forming a solid cruciform post. In a post composed of four flanged pieces, as in Figure 7, (Both 1,) the material is disposed away from the centre toward the periphery or outline, forming a hollow post.

X-Q. 26. What figure on that plan (Both 1) indicates the first
260 divergence from the post made of angle-irons as above, and exhibits the principle of the piece used to form a hollow post?

A. Figures 3, 5, 8, 9, and 12.

X-Q. 27. What was the novelty in the use of the peculiar angle-irons to connect the principal parts of the column, as in "Allgemeine Bauzeitung?"

A. The novelty consists in the same thing as pertains to our several posts, to wit, to form hollow columns.

X-Q. 28. Do you think there was no novelty in the plan for forming a column with the peculiar angle-irons without the use of the centre pieces; that is, would the dropping of the centre pieces have nothing of novelty?

A. The answer given to question 17 in chief is an answer to this question.

X-Q. 29. I believe you have not, in that answer, referred to novelty, have you?

A. "In my opinion the principle of the post remains the same whether the flat bars are or are not inserted between the flanges—it being in both cases a hollow wrought-iron column of flanged pieces. That the insertion of the flat bars does not affect the principle is distinctly stated in the patent of Mr. Reeves."

X-Q. 30. Am I to understand you as thereby asserting there is no novelty?

A. Before our invention in 1860 a column made as in Figure 6 I would consider a novelty.

X-Q. 31. I should infer, from your answer, that you consider that your invention of 1860 is the thing that precludes a claim to novelty in the formation of a column out of the peculiarly-shaped angle-irons, discarding the centre pieces?

A. We invented, in 1860, hollow columns made of flanged pieces riveted through the flanges. Since Figure 6 would be such a column of later dates, it would not be to us a novelty.

X-Q. 32. Cross-question 31 repeated.

A. It would not be, because of our previous invention.

261 X-Q. 33. In what document will a description of your alleged

invention of 1860 be found to which the public ever have had access?

A. Firstly, our sketches and drawings were public in our office, and were seen by a great many persons in 1860 and 1861; secondly, in our letters-patent dated January 14th, 1862, and in our patent of October 31st, 1865, where our invention is set forth, as I have stated in my previous direct examination.

X-Q. 34. Looking at Figure 8, (Both 1,) say whether the dropping of the flat bars from the section, and using only the peculiar-shaped angle-pieces, this latter combination would be a novelty, as compared with the section as represented by Figure 8.

A. My answers to cross questions 28 and 29 are repeated as an answer to this question.

X-Q. 35. You misunderstand the question. Your opinion is asked as to whether such a change as indicated in the question would, in your opinion, constitute a novelty irrespective of any other invention.

A. I would not consider that it would constitute a novelty.

X-Q. 36. If you do not consider that the discarding of the centre-pieces would constitute a novelty, explain, if you please, why it is that columns are now constructed without centre pieces, and why it is considered better to put the material in the flanged pieces rather than in the centre.

[Objected to, inasmuch as the question assumes that columns (generally) are constructed "without centre pieces," and that "it is considered better (generally) to put the material in the flanged pieces," &c.]

A. Previous to 1860 cruciform columns were made both with and without interposed flat bars or centre pieces. It was shown by us in 1860 that the material in the flanged pieces acted with greater efficiency as they were removed from the centre towards the periphery, and the hollow space increased. This also agrees with theory.

262 The pieces between the flanges are often used for convenience in forming connections with other parts of structures; their insertion or rejection does not, in my opinion, affect the principle of a hollow post.

X-Q. 37. Having seen the results of the trials of Phœnix posts at Pittsburg and at Phœnixville, do you still believe the trial of the Phœnix column, referred to in the Exhibit A annexed to your answer to the bill, in which it was represented to have given way at about ten and a half tons load per square inch of its section, a reliable experiment or not?

A. I saw the results of the trial of one of the posts at Pittsburg, similar to the post tested afterwards at Pittsburg, when Mr. Griffen was present. The results of the trial at Phœnixville, as stated in Mr. Griffen's testimony, differ very materially from the results of those trials as officially reported to General Serrell, as made to him by his chief assistant, Juan Patterson, under whose supervision, and at whose instance, the tests were made. I do not recollect the exact pressure per square inch any of those colums bore before deflection could be measured. I noticed in the experiments I made in the Reeves post that it began to deflect at the pressure indicated; and I copied those notes myself, from careful inspection of the post under test, and examination of the mercury and spring-gauges attached to our machine. This test occurred soon after we commenced using that machine, and I cannot entertain the same confidence in the indications of the gauges used at that time as I previously did. I since find by experience that their indications are very uncertain, and my impression is that a column of

that dimension should support a greater pressure than ten and a half tons per square inch before deflecting.

X-Q. 38. Look at the Figures 7 to 9, in Exhibit A, attached to your answer, and Figures 10.5, and say whether one or the other of those is incorrect; and, if so, which?

(Objected to, inasmuch as the counsel for complainant does not furnish to the witness the exhibit referred to in his question.)

263 (Mr. McMurtrie replies that he furnishes the printed copy of the answer furnished herein by Mr. Collier.)

(To which Mr. Collier replies that he did not print said answer, nor has he compared the printed copy with the original.)

A. Taking 9.18 the divisor, 79 the dividend, and 10.5 the quotient, the divisor being assumed to be correct, either the dividend or quotient is incorrect.

J. H. LINVILLE.

Sworn and subscribed to before me this 27th day of September, 1870.

JOHN RODGERS,
Examiner.

DECEMBER 5TH, 1870.

Present: Mr. Collier, Mr. McMurtrie.

JONATHAN R. JONES, being duly affirmed, saith:

Question 1. Where do you reside, and what is your occupation?

A. I reside in Conshohocken; am a civil engineer by occupation.

Q. 2. Have you read the letters-patent of Samuel J. Reeves, sued on in this cause, and examined the drawings annexed to it?

A. I have.

Q. 3. Look at defendant's exhibit, "Trautwine 1," and state what it is intended to represent, and whether it does correctly represent that for which it was designed?

A. It is intended to represent a column or post, the segments of which have the same area as one of the smaller segments rolled by the Phœnix Iron Company, as shown in their lithographic circular, exactly similar in configuration to Figure 4 in the letters-patent of Mr. Reeves, and having flat bars interposed between the flanges, and extending outwards from the centre, as suggested in Mr. Reeves' patent, in the

264 last paragraph thereof preceding the claim of the patent. I believe the model correctly represents that which it is designed to represent.

Q. 4. Look at defendant's exhibit, "Trautwine 2," and state what it is intended to represent, and whether it does correctly represent that for which it is designed.

A. It is intended to represent, and does faithfully represent, as I believe, one of the forms of the post described in the text, and shown in the drawings of "Allgemeine Bauzeitung." It is made to the scale, except as to length, which is much shorter than the post described in the work. The particular combination represented by this model is post designated G, in the Plate 440 of said work.

JONATHAN R. JONES.

Sworn and subscribed before me this 5th day of December, 1870.

JOHN RODGERS.
Examiner.

265 Circuit court of the United States, eastern district of Pennsylvani

SAMUEL J. REEVES
vs.
HTE KEYSTONE BRIDGE COMPANY ET AL. } In equity.

It is hereby agreed, that at the hearing of this cause, the defendants under the issue of want of novelty of the complainants' patented improvement, may offer in evidence, with like effect as though the same had been regularly pleaded, that portion of the printed publication entitled "Allgemeine Bautzeitung," &c., by Foster, (Vienna, 1861,) which is referred to in the testimony of J. H. Linville, (answer to question 12 in chief,) and the plates accompanying said work, referred to also in said testimony.

R. C. MCMURTRIE,
For S. J. Reeves.

CHARLES B. COLLIER,
Of Counsel for Defendants.

PHILADELPHIA, August 9, 1870.

266 And afterwards, to wit, on the sixteenth day of October, 1871, the following agreement of counsel was filed:

It is agreed that the following documents, drawings, and models may be read or used in evidence on the hearing, in the manner and with like effect as if the same had been produced before the examiner, proved and duly certified by him as part of the proofs. The patents referred to in the pleadings with the drawings annexed. The books and plates referred to by the witnesses, viz. Grantham Hodgkinson, Dempsey
267 Tredgold, Latham Haupt, Clark Recuile —— Humber, —— Weale.

The correspondence between the parties and memoranda on their books referred to and extracted in the pleadings, or in the pleadings No. 4, April S., 1868, viz:

Letters: Linville to Reeves, Jan. 1, 1863.
" Reeves to Linville, Jan'y 5, 1863.
" Linville to Reeves, Jan'y 6, 1863.
Telegram: Linville to Reeves, Jan. 19, 1863.
Letter: Reeves to Linville, Jan. 19, 1863.
268 " Linville to Reeves, Jan. 28, 1863.
" " to Phœnix Iron Co., Jan. 28, 1863.
Mem. or order book of Phœnix Iron Co.
Letters: Letters to Piper, Feb. 17, 1863.
" to Linville, Sep. 24.
" " " Dec. 7.
" Linville to Reeves, March 18, 1864.
" "
" 21, "

Models and drawings referred to by
Crengar.
Trink.
Piper.
269 Linville.
Murphy.
Griffin.
Bonzano.

Walter.
Both.
Trautwine.
The Algemeine Bautzeitung.

Also that a document marked —— described as Novel Album des divers Fers, speciaux de Dupont & Dreyfus, &c. And a model of the subject of the drawing therein contained, with the same effect as if due notice had been given of the intention to produce the same in
270 evidence to show prior invention, as required by the act of Congress.

THEO. CUYLER,
For K. Edge Co.

R. C. McMURTRIE,
For Phœnix Iron Co. & S. J. Reeves.

271 And now, to wit, this 10 day of April, A. D. 1872, this cause having been brought to final hearing upon the pleadings and proofs, and counsel for the parties respectively having been heard thereupon, and the same having been duly considered by this court, it is hereby ordered, adjudged, and decreed that the complainant's bill be dismissed with costs. Per curiam.

272 And now, to wit, November 30, 1872, the complainant appeals from the decree of the court made in the above case April 10th, 1872, dismissing the bill with costs, to the Supreme Court of the United States sitting at Washington, to the next term thereof.

THEODORE CUYLER,
Solicitor for Appellants.

273 United States of America, Eastern District of Penna.:

I, Samuel Bell, clerk, certify the foregoing to be a true and faithful copy of the record and proceedings of the circuit court of the United States in and for the eastern district of Pennsylvania, in the third circuit, in a certain suit in equity therein lately depending, wherein The Keystone Bridge Company were complainants, and The Phœnix Iron Company et al. defendants.

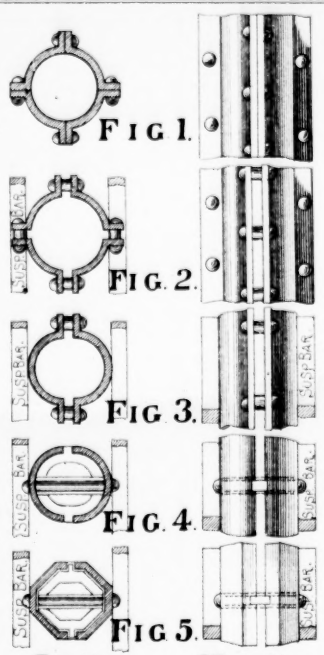
In testimony whereof I have hereunto subscribed my name and
275 affixed the seal of said circuit court of the United States at Philadelphia this thirtieth day of November, A. D. 1872, and the ninety-seventh year of the Independence of the said United States.

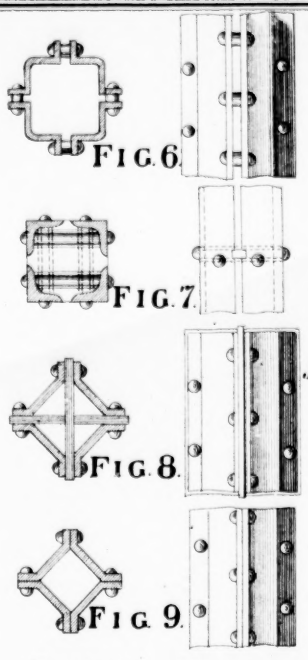
[SEAL.] SAMUEL BELL,
Clerk Cir. Ct. U. S., E. D. of Pa.

(Indorsement on cover:) No. 358. The Keystone Bridge Company, appellant, vs. The Phœnix Iron Company. E. Penn'a. C. C. U. S. Filed 10th December, 1872.

Keystone Bridge Company Page 275
vs.
Phoenix Iron Company
No. 358

LINVILLE EXHIBIT, No. 1.





Figures referred to in J. H. Linville's Testimony

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